MAR 1937

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Control of Great Floods

By Arthur E. Morgan

Also In This Issue:

Early Work at Seminoe Dam

Fighting Subgrade Swelling on Roads

Dredge Fill for San Francisco Fair

Practical Soil Mechanics for Small Dams

Design of Schools Safe Against Earthquakes

Seminoe Canyon on the North Platte River in Wyoming where work has begun on Seminoe Dam. The cableway above the dam will span from the shelf at the right of the picture to a shelf cut in the canyon side to the left of the tree. The concrete plant is at the left.

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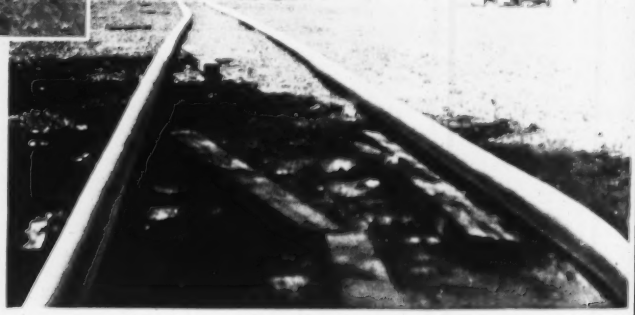

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A Bill to *Foster Construction Recovery*

LEST those who live by construction become unduly absorbed in some of the more spectacular legislative activities at Washington, it is worth while to notice here one bill, the passage of which might mean far more to them than would some of those that are making the first pages. It is the Beiter Bill (H. R. 4594), which is intended to amend the Revenue Act of 1936 with respect to the surtax on undistributed profits.

Under last year's revenue act, undistributed earnings are taxable at rates that may run as high as 27 per cent. The act makes no exception in favor of earnings that may be plowed back into new construction, or expansion and replacement of plant; the tax must be paid on the undistributed earnings before they are available for such purposes. The amendment introduced by Congressman Beiter is designed to permit the deduction of such expenditures before the tax is figured.

OBVIOUSLY the construction industry is concerned with such a program on two counts: first, because it is the nature of the industry to build up its organizations out of earnings. Most contractors and construction companies begin small with a single contract or two or three. Capital usually is limited. Out of his earnings each contractor must begin to build his plant and provide for holding his organization together until he lands his next job.

Surely here is a business in which the plowing back of earnings is almost the one recipe for sound growth. And here is an industry of which the technical progress must depend on the contractor's ability to finance modernization of plant and methods out of his earnings. Arbitrarily to prevent this not only puts a premium on imprudent financing of construction as a business; it penalizes the technical progress of a basic function in our economy. A consistent advance in construction efficiency is a matter of vital concern to the entire process of capital investment.

And this brings us to the second reason why construction has a heavy stake in this amendment to modify the tax on undistributed earnings. Many other industries, although not subject to the same compulsion as is construction, find it prudent at times to finance capital improvements out of earnings rather than by increasing their funded debt or outstanding stock.

This is one of those times. Today, the country as a whole, including the federal government, is watching hopefully the rising volume of private construction that will make possible the curtailment of heavy federal expenditures. But in its zeal to invest new capital, private enterprise naturally will be governed by the hazards of financing it. And if it be made possible to finance out of current earnings new construction and other improvement of plant and equipment, many more such projects will be undertaken.

LOOKING for a moment at the government side of the picture, it must not be assumed that the exemption of such earnings as might thus be plowed into capital plant would mean a net loss of the tax thus avoided. There are offsetting factors. The employment thus created in private industry would reduce the burden of relief and work relief. The added normal taxes that would be collected from construction organizations and from the manufacturers of machinery and materials as a result of the new business thus stimulated would help to make up for any loss of revenue. Taxes collected on the incomes of all those who find employment on such work also would build up in normal, healthy fashion a revenue that otherwise could not be realized.

Today the construction industry and the entire business world is heartened by the progress of the last year or more; and the most encouraging aspect of the picture is the part that has been played in that recovery by private enterprise. The Beiter amendment to the undistributed earnings tax would be a substantial impetus to that trend. Every employer and every employee who has a stake in the construction industry will find it well worth while to interpret to his representatives in Congress the two-fold significance of this measure.

Willard Chevalier

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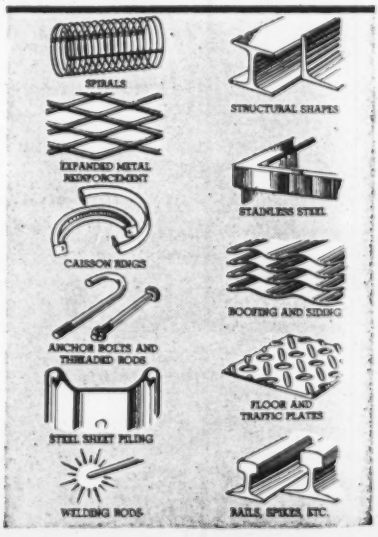

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March 18, 1937

Seminoe Dam

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Skimming Fresh Water from Salt—Salting of wells in Hawaii due to increasing draft on underground resources has resulted in the development of a new method of obtaining supplementary supplies in which fresh water is skimmed from the top of artesian basins overlying the heavier salt water underlying the islands. The method will be described in our issue of March 25.

"CONCRETE MARKERS WILL SAVE US MONEY-

Installation of precast Atlas White traffic markers in Patterson Boulevard, Dayton, Ohio, was under the direct supervision of Rollin C. Gaylord, Maintenance Engineer of Division of Streets

...In 3 Years' Time the Cost of Painted Lines Will Equal Cost of White Cement Markers"

—H. P. ULLMER, *Superintendent of Streets, City of Dayton, Dayton, Ohio*

SUPERINTENDENT ULLMER, commenting on the installation of precast Atlas White concrete traffic markers in Dayton, says—

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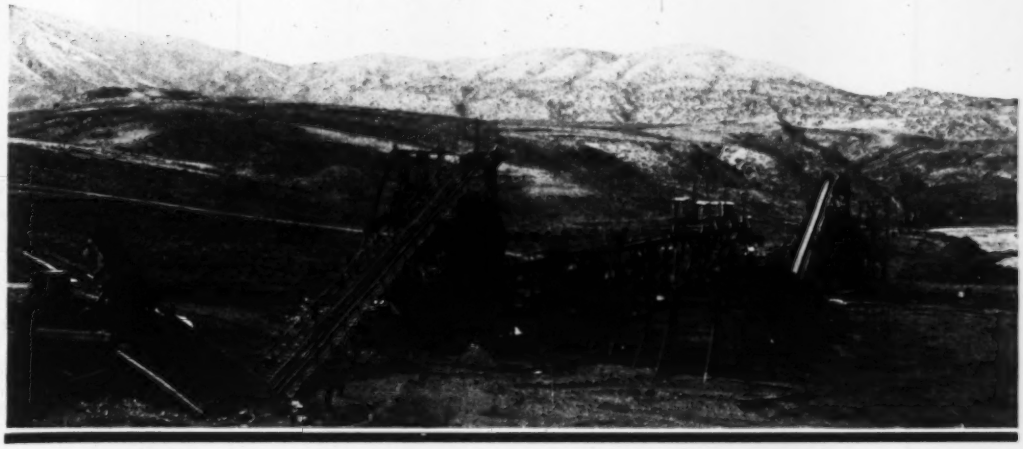


FIG. 1—SEMINOE AGGREGATE PLANT, 2¼ miles upstream from the damsite. A tramway, with its loading terminal beyond the storage bins, extends over the low ridge in the right background to the concrete plant.

Seminoe Dam

I—Site Exploration and Design Studies

By Kenneth B. Keener

Designing Engineer on Dams
U. S. Bureau of Reclamation
Denver, Colo.

▼

Concrete arch dam on the North Platte River in Wyoming will store water for the Casper-Alcova irrigation project and provide a head for power generation

SEMINOE DAM on the North Platte River in Wyoming is being built for the dual purpose of irrigation and power development. It will provide storage water for the Casper-Alcova irrigation project, now under construction in the vicinity of Casper, Wyo., with diversion at the Alcova Dam. There is a present demand for additional power in southern Wyoming and northern Colorado, which will be met by the completion of the power plant which, except for the installation of hydraulic and electrical machinery, is to be built under the existing construction contract. The average annual production of firm power will be 130,000,000 kw. hr. Secondary power is expected to average about 30,000,000 kw. hr. The reservoir created by the dam will have a storage capacity of 1,020,000 acre-ft.

Early investigations for the required storage embraced a careful search along the North Platte River from Walden, Colo. to Casper, Wyo. Reconnaissance surveys and studies indicated that the most feasible site from the standpoint of economy, geology and storage possibilities was located in the Seminoe Canyon, whereupon the investigation work was concentrated on sites in this canyon. Final determination was made after geological examinations and foundation explorations in the vicinity of the present construction.

A brief description of the geologic and topographic feature known as the "Hanna Basin" in south central Wyoming will aid in understanding the reasons back of the selection of the damsite. Roughly, this basin with an area of 900 sq. mi. has a long diameter of 40 mi., bearing 35 deg. northwest, and a transverse diameter of 30 mi. The rim consists of upturned sedimentary rocks, which have a pronounced slope to the North Platte and Medicine Bow rivers which have their confluence within the basin. The Seminoe Mountains on the west of the Seminoe Canyon and the Freezeout Mountains on the east constitute the north rim, through which the North Platte River has cut the basin outlet. Upheaval of the Pre-Cambrian granite formed these mountains and uplifted the overlying sedimentary rocks so that the dip southward varies from 35 deg. at the canyon mouth to 60 deg. midway of the canyon.

The sedimentary strata overlying the granite consist of the Deadwood formation, largely sandstone, the Madison limestone, the Amsden formation, both limestone and sandstone, and the Tensleep sandstone. Each formation is 200 ft. or more in thickness, and as these tight beds underlie the storage area of 20,000 acres in the western part of the natural basin, reservoir seepage loss should be negligible. A sharp fault bearing due east and west has resulted in duplicating surface exposures of the upturned sedimentary beds and the granite in the upstream half of the Seminoe Canyon. One of the sites given careful geologic examination was situated near the upstream end of the canyon where the foundation rock and left abutment for the structure would have been cherty limestone of the Madison formation and the upper portion of the right abutment would have been in the red beds of the Amsden formation. While this site appeared feasible it was discarded in favor of the present site, where it was apparent that the depth to rock sufficiently solid for foundation purposes would be less.

The damsite finally selected at the center of the length of the canyon is entirely in granite. Prior to the time of awarding the construction contract,

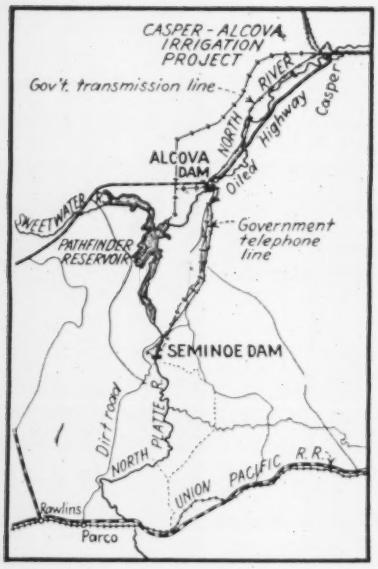


FIG. 2—SEMINOE DAM is located on North Platte River southwest of Casper Pathfinder Reservoir. Alcova Dam, which diverts water for the Casper-Alcova irrigation project, is below and just upstream from the Pathfinder Dam.

the foundation investigation comprised seventeen diamond drill holes with an aggregate total vertical depth of 1,830 ft., four vertical shafts with a total depth of 175 ft. and eight horizontal drifts into the abutments with a total length of 235 ft. Five of the drill holes were directed at angles and the greatest vertical depth attained in one of these was 188 ft. The lowest elevation reached was by means of a vertical hole in and 145 ft. below the river bed. The foundation investigations covered an overall reach of 900 ft. and were sufficient to determine the suitability of the site, the final location within the investigated area and the general type of dam. Further investigations by drill holes and drifts, now in progress by the construction contractor, will determine more closely the final structural design of the dam and the detail requirements for foundation grouting and drainage that will be necessary.

The dark gray granite bedrock is extremely hard and durable but is broken by numerous seams and fractures, the latter doubtless resulting from the heavy uplifting movements during the formation of the mountain ranges. The more prominent joints dip 50 deg. south while others equally pronounced dip 40 deg. north, so that the principal joint systems are practically normal to each other. Although smaller randomly-oriented joint systems are frequent, investigations indicate that these tighten up to close joints at moderate depths. The solid rock of the left abutment rises on a slope of almost ¼:1, the toe for a height of 100 ft. above river bed being obscured by a heavy talus. The right abutment, against the toe of which the narrow river channel is formed, has an irregular slope averaging ¼:1. The river fill of sand, gravel and boulders over the bedrock is 25 ft. in depth.

Preliminary designs

Although the comparatively narrow U-shaped section across the site suggested its adaptability for the concrete-arch type of dam, a straight gravity type was also investigated. The section of the latter had a downstream slope of 0.67:1 and an upstream slope of 0.123:1 and an abutment-section crest width of 20 ft. The spillway was of the overflow type, located in five bays along the central portion of the dam, the overflow in each being controlled by a 28x12½-ft. radial gate. A thick concrete apron with dentated sill at the downstream end was extended 150 ft. downstream from the toe of the dam to prevent erosion. The outlet works and power penstocks were provided for by a 21-ft. diameter concrete-lined tunnel around the right abutment, the power plant to be located 600 ft. downstream from the dam.

The arch-dam layout also included the same outlet and power plant features, but the spillway consisted of a separate inclined tunnel, also located through the right abutment and discharging into the river 250 ft. downstream from the dam. The spillway inlet was of the side-channel, overflow type, controlled by five 28x15-ft. radial gates mounted between piers on the crest. The maximum section of the arch dam, with a vertical upstream face, had a top width of 15 ft. and a base width of 105 ft. for a 270-ft. maximum height, the downstream slope with the horizontal being progressively reduced as it approached each lower elevation. Downstream fillets were provided for the reduction of abutment stresses. Comparative estimates prepared in 1932 for the preliminary alternative types of dams described indicated that the cost of the gravity type would exceed by well over one-third the cost of the arch-type layout. Thereafter, all designs, plans and investigations were based on the arch type of dam being constructed.

Contract designs

When the construction specifications were first issued, the drawings showed a constant-angle type of arch dam with a gravity tangent at the right abutment. In the interim between the rejection of bids and the readvertisement a more thorough field investigation of abutment conditions was made. This resulted in making a new design and layout in which the gravity tangent was eliminated and the concrete yardage was slightly reduced. This design, still of the concrete-arch type, was used in the readvertisement of the construction specifications. The crown section, which is also the section of maximum height, has a height from foundation to roadway of 261 ft., a vertical upstream face, a downstream slope of 0.268:1, a theoretical crest width of 15 ft. and a base width of 85 ft. The upstream face is laid out on a constant radius of 200 ft. but the downstream radii are shortened and the centers moved progressively upstream with lower elevations, so that the horizontal sections become wider as the abutment contacts are approached. Concrete parapet walls 3½ ft. high will run the full length of the 560-ft. crest inclosing a 12-ft. roadway with narrow curbs 6 in. higher in elevation on each side.

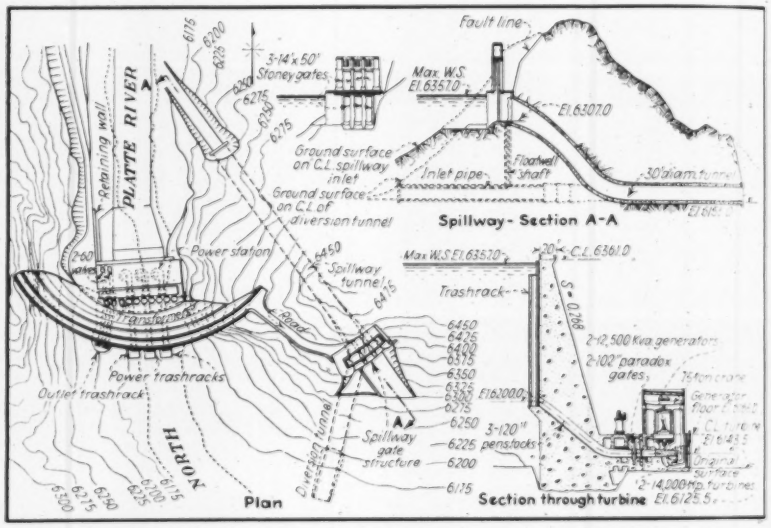


FIG. 3—THE DAM is to be an arch structure, 261 ft. high above the foundation. Its spillway is to be into a tunnel used for diversion purposes during construction.

The dam will be divided into 50-ft. panels, and the intervening joints will be formed to provide interlocking keys. Each of these contraction joints will be provided with grout stops and uniformly spaced grout outlet boxes, connected to a system of small diameter imbedded pipe through which grout will be pumped under pressure into the joints, after the temperature of the concrete has been reduced below mean annual air temperature.

Cooling

In reducing the temperature resort will be had to artificial cooling. While the concrete in a dam of such a thin section would shrink under natural conditions to its normal volume in two or three years, there are certain definite advantages in hastening the process. One of these is in averting the unusually high temperature gradient between the center of the concrete mass and the exposed surfaces, which would exist under natural conditions during the winters. These surfaces will be well below freezing temperature for three months of the year. Another is the reduction of the temperatures uniformly to a lower average temperature by the time of grouting than would be effected naturally, resulting in uniform shrinkage and uniform maximum opening of contraction joints. These two advantages are of especial importance in that cracking of the concrete is reduced to a minimum, which is of decided importance in an arch dam. A further advantage of cooling lies in the avoidance of any undue delay in filling the reservoir which is being created for holdover storage. If the concrete were allowed to cool naturally, the larger portion of the valuable storage would have to be released to permit grouting the contraction joints under favorable conditions.

To provide for cooling, tubing of 1 in. outside diameter will be laid in horizontal coils on the surface of each 5-ft. concrete lift, shortly before placing the succeeding lift. Assembly will be in loops parallel to the axis of the dam and such as to effect a 5½-ft. spacing between the tubing. These coils, each within a block between contraction joints except for short blocks at the abutments, will have their inlet and outlet ends on the upstream face of the dam.

The cooling medium will be river water circulated at a velocity of not less than 2 ft. per sec. through each coil. Pumping will begin shortly after concrete placement in the lift above the coil. During the period suitable for placing concrete, from April to November, the temperature of the river water is expected to vary from 32 to 56 deg. F., the maximum being during July and August. By early circulation and the use of a moderately low-heat cement, it should be possible to keep the maximum temperature of the concrete, occurring three days after placement, below 90 deg. F.

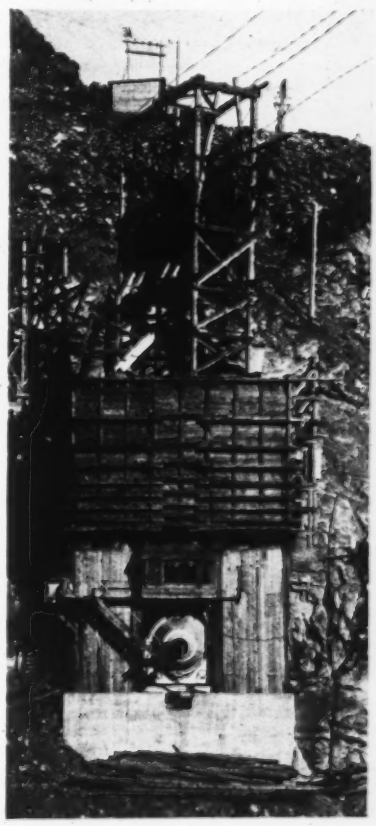
Studies and experimental work leading to the design of the Boulder Dam cooling system, together with the satisfactory results obtained there, give assurance that the cooling equipment and procedure planned for Seminoe Dam will give equally satisfactory results. In general the plans are the same, in that, although there is some difference in the detailed arrangement, the size of cooling pipe and the vertical and horizontal spacing of the pipes are the same. The lower temperatures of the river water and of the air at Seminoe Dam are such that there will be no need for using refrigerated water for a cooling medium, such as was done in the second stage of cooling at Boulder Dam.

Grouting

A grout curtain will be constructed in the foundation rock below the heel of the dam. This will be made by grouting from 1⅞-in. holes on 5-ft. centers drilled normal to the profile of the axis of the dam. It is expected that these holes will vary from 50 to 100 ft. in depth, each alternate hole being deeper, although more complete foundation conditions determined by the drilling will doubtless affect final decision as to the depth of the holes. Grout will be pumped into the holes after all concrete required within a radius of 50 ft. and to a thickness of not less than 10 ft. has been placed. Grout connections will consist of 2½-in. steel pipe imbedded in the concrete between the top of the hole in the foundation and the upstream face of the dam. Pumping pressures will be in the range between 100 and 500 lb. per sq. in. dependent upon foundation conditions. The successive-stage method of drilling and grouting may be adopted for portions of the curtain, i.e., drilling the holes to partial depth, washing out the holes before the grout has set and then drilling and grouting in successive stages at higher pressures.

After foundation grouting has been completed, 4½-in. drainage holes on 10-ft. centers will be drilled 5 ft. downstream from the grout holes. These holes will be drilled with a sharp downstream dip to depths of 30 ft. or more, through 6-in. steel pipe imbedded in the concrete from the upstream face of the dam to the hole location. After drilling each pipe will be capped, drainage water release being provided by a branch 2½-in. steel riser pipe, which will connect by a horizontal collecting header with one of two 8-in. outlet drains running radially to the downstream face of the dam. Internal drainage will be accomplished by imbedding 3-in. porous concrete drain tile vertically on 10-ft. centers, 5 ft. downstream from the axis of the dam. These drains will have outlets directly into the horizontal headers which collect the foundation drainage flow.

FIG. 4—MIXING PLANT with the aggregate bunkers and tramway terminal above it.



Spillway

The sharp right bend in the canyon immediately upstream from the damsite, together with the high cliff above the right abutment, dictated the tunnel-type of spillway through the right abutment as being the most economical. In addition to the side-channel inlet with crest controlled by radial gates as described above, consideration was given to a vertical shaft inlet with the circular crest controlled by a ring gate, similar to the type constructed and in successful operation at the Owyhee Dam in Oregon. However, the steep topography lent itself to the construction of an inclined tunnel inlet structure, which was adopted for final design. Flow over the crest will be controlled by three 14x50-ft. structural-steel Stoney gates, electrically operated from a gate house directly above. Discharge will be into an inclined shaft, which will drop 150 ft. in 240 ft. and connect with the horizontal leg of the tunnel extending for 320 ft. to a short open channel converging with the river channel at an angle of

30 deg., 400 ft. downstream from the toe of the dam. The tunnel, after its transition in the inclined shaft from a large horseshoe section, will have a normal circular section, 30 ft. in diameter. It will be concrete lined throughout and after concrete placement the surrounding rock will be pressure grouted through 1⅛-in. holes drilled radially to depths of 20 ft. Spacing of these radial grout rings, each calling for not less than eight holes, staggered in alternate rings, will be 20 ft. along the length of the tunnel. The spillway is designed for a capacity of 50,000 sec.-ft. at full reservoir head, which amounts to 6.75 sec.-ft. per sq. mi. of drainage area.

The construction contract provided that the diversion tunnel to be excavated by the contractor should discharge into the spillway tunnel at the lower end of the inclined shaft and could be excavated to the dimensions necessary to meet his diversion requirements. When diversion of the river is no longer required, the tunnel will be unwatered and plugged for more than 100 ft. at its downstream end, which is being constructed to a circular concrete-lined section. The plug will consist of concrete placed in a series of wedge-shaped sections, within which a system of pipes will be imbedded for grouting the contacts after the concrete has shrunk. The contractor chose a 27-ft. excavated diameter horseshoe-shaped section for the tunnel upstream from the plug. On account of the unexpected disintegrated nature of the material encountered this diversion tunnel will be lined with concrete.

Outlet works

Release of required irrigation water down the river will be accomplished by imbedding two 72-in. welded plate-steel pipes just left of the center of the dam. These pipes, parallel and spaced 13 ft. on centers, will extend 60 ft. downstream from the dam, where the flow will be regulated by 60-in. differential needle valves, above which a portion of the power house will serve as a valve-operating house. Each outlet pipe will be provided with a 72-in. circular emergency gate valve installed between the valve house and the dam. The inlets to the outlet conduits will be protected by a concrete and structural steel trash-rack structure supported on the upstream face of the dam. The outlet capacity under full reservoir head will be 2,850 sec.-ft.

Power plant

The power penstocks, consisting of three 120-in. welded plate-steel pipes, will be imbedded in the concrete at the right of the center of the dam, and the power house will be constructed immediately downstream over the present river channel. Individual concrete and structural-steel trash racks will be installed in front of the penstock inlets on the upstream face of the dam. Flow through each penstock will be controlled by a 102-in. motor-operated gate valve installed in the pipe between the power house and the dam. A single structural-steel bulkhead gate, 15 ft. 4 in. x 11 ft. 5½ in., operated and shifted from one intake to another by means of a gantry crane on top of the dam, will be provided for emergency closure of any penstock. The first installation of hydraulic and electric machinery will be for the completion of two units only, the third penstock being reserved for a future unit when the power demand justifies its installation.

Contract for furnishing the two vertical-shaft hydraulic turbines was awarded to the Pelton Water Wheel Co., of San Francisco, Calif., on Oct. 6, 1936. Each of these units will have a capacity of not less than 47,000 hp. at full gate opening when operating at 225 r.p.m. under a net effective head of 113 ft. As this head increases the turbine output will increase up to a maximum of 15,000 hp. at full gate opening under a net effective head of not more than 171 ft. Award for furnishing the two alternating current generators was made to the Allis-Chalmers Manufacturing Co. of Milwaukee, Wis., on Oct. 6, 1936. The rating of each will be as follows: 12,000-kva. capacity; 90 per cent power factor; 60-cycle frequency; 3-phase; 6,900 volts between phases, and a speed of 225 r.p.m.

Step-up transformers will be placed on a concrete platform between the power house and the dam. The main power house building will be 46x128 ft. in plan, and a half-height extension, 46x30 ft., will be built at the east end. The former will have a 75-ton traveling crane running the full length of the building.

Progress of designs

The foregoing portion of this article has not only briefly followed through the investigations to determine a suitable damsite but has brought out the stages of design development, before proceeding with a description of the contract designs. It is the usual occurrence with a structure of this size and importance that the designs are not final until construction is completed. At this writing (Jan. 16) foundation conditions are being uncovered at the damsite which may result in some revision of the contract designs.

While the general type of dam was selected on the basis of the shape of the canyon cross section and the geological conditions, the selected type was analyzed by the trial-load method and adjustments made to obtain a structure with safe working stresses. In this method assumption is made that the structure is homogeneous and that the loads are transmitted to the foundation and abutment rock by arch and gravity action. The effects of earthquake shocks and of temperature variations are also taken into account in the distribution of loads for calculation of stresses (See *ENR*, Jan. 22, 1931, article by H. M. Westergaard for a description of this method).

Construction facilities

The government has designated certain deposits in and near the river channel in the reservoir area where concrete aggregate may be obtained by the contractor. The principal deposit, lying between four and six miles upstream from the dam, averages 7 ft. in thickness and is estimated to contain 200,000 cu. yd. of sand and gravel. In general all other materials to become a part of the completed work, such as cement, gates, hoists, pipe and reinforcement bars, are to be furnished by the government on cars at Parco, Wyo. From this point the contractor must haul them over an unimproved road to the damsite, 37 miles northeast. The government has constructed a 66,000-volt transmission line from Casper to the damsite, which the contractor is using in transmitting power for construction purposes. After completion of the work this line will be used permanently in distributing power generated at Seminoe Dam.

Bids for the construction of Seminoe Dam and power plant were first opened by the U. S. Bureau of Reclamation on July 22, 1935, as a PWA project. Due to changes deemed advisable affecting the specifications, contract was not awarded and the work was readvertised as a WPA project, bids being opened on Nov. 26, 1935. Award was made to the low bidder, a combination of the Morrison-Knudsen, Utah Construction and Winston Bros. construction companies, the total amount bid being $2,819,459.

Actual construction at the damsite was commenced on Feb. 20, 1936, when a 2-yd. shovel began excavation of the talus slope at the left abutment. Excavation of the spillway tunnel was commenced in April and was nearing completion at the end of the year. The contractor commenced excavating his diversion tunnel in September and this was practically completed during December. Some excavation on the top of the left abutment was accomplished in the fall but this was discontinued and excavation started on the right abutment late in December. Tailrace excavation for the power plant, involving a lowering of the river channel, was being actively prosecuted at the end of the year. The first concrete work will be the lining of the diversion tunnel and horizontal leg of the spillway tunnel, which it is planned to accomplish during the coming spring and summer.

The estimated principal quantities involved in the construction of the dam and power plant are as follows: excavating 575,000 cu. yd. of all classes of material in open cut; excavating 22,000 cu. yd. of spillway tunnel; drilling 30,000 lin. ft. of grout and drainage holes; placing 185,000 cu. yd. of concrete, 161,000 cu. yd. being mass concrete in the dam, and installing 6,000,000 lb. of gates, pipes, reinforcement bars, structural steel and other metal work.

Construction of the Seminoe Dam and the entire Casper-Alcova Project was delegated to the U. S. Bureau of Reclamation by Secretary of the Interior, Harold L. Ickes, while the late Elwood Mead was commissioner of the bureau. John C. Page is now commissioner. All engineering and construction work of the bureau is supervised by R. F. Walter, chief engineer, and S. O. Harper, assistant chief engineer, located at Denver, Colo. J. L. Savage is chief designing engineer and W. H. Nalder, assistant chief designing engineer, for the bureau. L. N. McClellan is chief electrical engineer. H. W. Bashore, with headquarters at Casper, is construction engineer for the Casper-Alcova Project, and J. H. Warner, located at the damsite, is resident engineer on the construction of the dam and power plant. The writer is in charge of the division of dams in the Denver office.

II—Construction Plant for Seminoe Dam

A 2½-mile aerial tramway brings aggregate to the damsite from the screening plant where a year's supply must be excavated from the river bed each autumn—Mixing plant on the steep hillside above the dam will supply concrete via rail to a cableway spanning the canyon.

By V. L. Peugh

Chief Engineer, Morrison-Utah-Winston Lawler Parco, Wyo.

A CONTRACT for the construction of Seminoe Dam was signed Dec. 14, 1935. During the working season of 1936 the spillway and diversion tunnels, comprising 30,000 cu. yd., were driven but not lined. Excavation for the spillway inlet and outlet, 50,000 cu. yd., was completed during the year, 45,000 cu. yd. of a total of 196,000 cu. yd. in the excavation for the dam proper was removed and 100,000 cu. yd. was excavated from the tailrace below the powerhouse. Excavation on the dam abutments, the tailrace and various roads around the dam is being continued this winter as the weather permits. In addition to the above mentioned work, a screening plant, tramway, cement receiving plant, mixing plant and cableway were built and 100,000 cu. yd. of raw unscreened aggregate was stored for use during periods of high water, when the material cannot be taken from the river bed.

The source of aggregate for the dam is the bed of the river from two to four mi. above the damsite. Owing to the ruggedness of the intervening country the shortest practical road to the lower end of these pits is 5 miles long and difficult to maintain. Since hauling aggregate to the damsite by trucks was out of the question, an aerial tramway, 13,000 ft. long, having a capacity of 125 tons per hour, has been constructed from the mixing plant to a loading terminal built in a convenient location near the downstream end of the gravel pits. This tramway delivers finished aggregate directly into bins over the mixing plant.

The aggregate screening plant also has a capacity of 125 tons per hour and is located at the loading terminal of the tramway. Two rotary screens are used which separate the aggregate into five sizes: sand, which passes through a No. 4 screen; No. 4 to ¾ in.; ¾ in. to 1½ in.; 1½ in. to 3 in.; and 3 in. to 6 in. All material is thoroughly washed by jets in the screens and the sand is washed and the silt removed in a double chain-drag type sand washer. Finished aggregate is delivered to stock piles, with the various sizes separated by bulkheads. A reclaiming tunnel is constructed under these stock piles, with a reclaiming belt running the length of the tunnel and up to the top of the bunkers in the loading terminal of the tramway.

FIG. 6—CONSTRUCTION PLANT at Seminoe Dam. Cement silo (A) with a tramway to the mixing plant (B) on a bench along which tramway cars carry concrete buckets under the cableway. The cableway head-tower operates on the bench (C). At the right, (D) and (E) are headings for the spillway shaft and diversion tunnels.

Raw aggregate can be removed from the river bed only in the autumn, after the flood season is over and before the ground is thoroughly frozen. Consequently, it is necessary to excavate enough material each autumn to care for concreting needs during the following year. This raw material is stockpiled on a large, fairly level area surrounding the gravel plant, where it is easily accessible for feeding the plant. Material is screened practically as it is

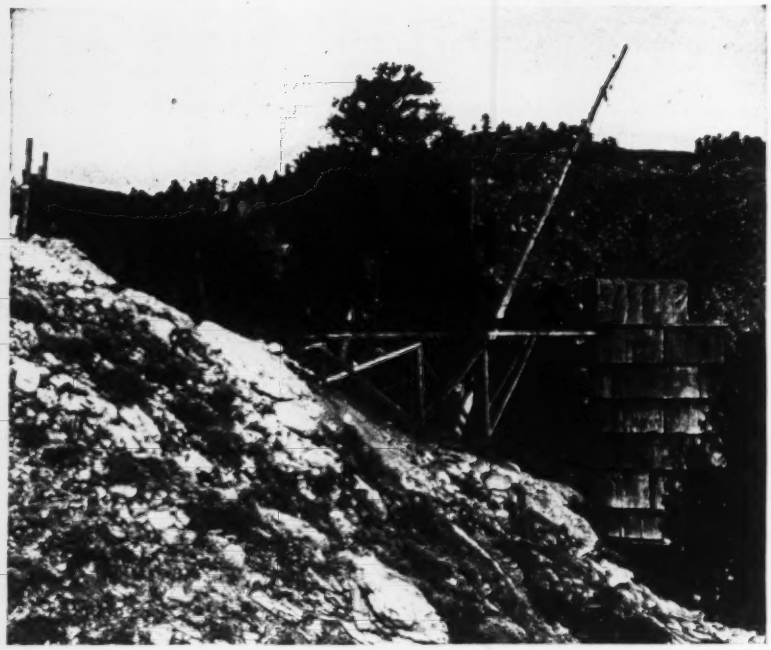


FIG. 5—BULK CEMENT comes to the top of the canyon in trucks which dump it into a hopper under the trestle at the left. From there a screw conveyor transfers it to the storage silo at the right. From beneath the silo a reversible tramway carries the cement to the mixing plant 700 ft. distant and 600 ft. farther down in the canyon.

used, only a few thousand yards of storage for finished aggregate being provided. The raw material is excavated from the river bed with a 1¾-yd. dragline and is hauled from one-half to two miles to the storage pile in trucks.

The mixing plant is located on a steep hillside, 400 ft. from the left abutment of the dam and slightly above the level of the top of the dam. It is equipped with one 4-yd. mixer, one 4-yd. weigh hopper for cumulative weighing of aggregate, a hopper and automatic scales for cement, an automatic water meter and instruments for making graphic records of aggregate, cement, water and consistency. Above the mixing and batching equipment are bins for each of the five sizes of aggregate and for cement. Directly over these bins is the discharge tower of the tramway. The tramway discharges into one large hopper from which the material is diverted into the proper bin by means of a revolving chute.

Cement will be delivered in bulk by the government at Parco, Wyo., 28 mi. from the job, f.o.b. cars. It is to be unloaded and delivered to the job by the contractor. A silo and pneumatic unloader have been provided at Parco. The haul to the job will be made in specially built tank trucks. At the job cement will be dumped into a hopper and moved by means of a screw conveyor to the top of a 3,800-bbl. steel silo, set on the hillside. This silo is 700 ft. distant and 600 ft. above the top of the mixing plant, delivery to which will be made by a single bucket, shuttle tramway, with a capacity of 75 bbl. per hour.

The mixer will dump directly into 4-yd. cableway buckets carried on a small standard gage car propelled by an 8-ton gasoline locomotive. From the mixing plant, the car will be run a distance of 400 ft. to a point over the left abutment of the dam and directly under the cableway provided for distribution of the concrete. At this point an exchange of buckets will be made, the cableway placing an empty bucket on the car and picking up a full one. The 565-ft. cableway, which has moving head and tail towers, is designed to carry a loaded 4-yd. concrete bucket, with the impact incident to rapid operation. The track cable is 2¼-in. lock coil. The carriage speed is 1,200 ft. per min., and the hoisting and lowering speed is 300 ft. per min. The cableway will cover all parts of the dam and power house. Concrete for the tunnel lining and for the spillway gate structure will be delivered by a pump machine which will receive concrete directly from the cableway or from a transfer car.

Excavation equipment on the job consists of one 4-yd. electric shovel, convertible to a dragline, one 2½-yd. diesel shovel, one 1¾-yd. diesel shovel, convertible to a dragline and one 1-yd. diesel shovel convertible to a dragline, also convertible to electric power for use in the tunnel. Four 10-yd. and three 5-yd. trucks are owned by the contractor; additional trucks are rented as required. Three compressors, with a combined capacity of 3,000 cu. ft. per min. furnish compressed air for the job.

A well equipped machine shop and a 300-man camp complete the major facilities.

For the Bureau of Reclamation H. W. Bashore is construction engineer in charge of the Casper-Alcova Project, with headquarters at Casper. J. H. Warner is resident engineer for Seminoe Dam. The dam is being constructed by an associated group composed of Morrison-Knudsen Co., Inc., The Utah Construction Co., Winston Bros. Co., and The Lawler Corp.

Details of New Waterloo Bridge In London Announced

THE demolition of Waterloo Bridge, one of London's most famous bridges spanning the Thames, (*ENR*, Sept. 3, 1936, p. 334), has now proceeded so far that bids are about to be invited for the new structure. Although the design of the new bridge was approved by the London County Council over two years ago, the highways committee of the council has since given further consideration to the details of the structure.

The bridge will have five concrete arch spans, each about 238 ft. long, compared with 120 ft. in the old bridge. The end piers will be placed in the river clear of the Victoria Embankment and of any future embankment on the south side of the river. The main characteristic of the architectural design is the wide span and shallow rise of the arches, which produce a light and extremely graceful appearance. The northern arch will accommodate the Victoria Embankment. Each span will consist of twin arches, spaced 33 ft. apart in the clear. The piers will be faced with granite, and their upper portions with Portland stone. The parapet also will be of Portland stone, surmounted by a white bronze balustrade, with lamp standards of the same material.

Two stairways will be built. That on the north side will lead to the Victoria Embankment and connect to a pedestrian subway beneath Wellington St. On the south side of the river the stairs will lead to the foreshore, and will be designed to suit a possible future embankment.

The lighting of the bridge, the width of the roadway and sidewalks, as well as the provision of a central strip remain to be settled, and will be the subject of further discussion with the Ministry of Transport.

Control of Great Floods

A task of unprecedented magnitude, flood control requires that every possible method be studied, including headwater and soil control * * * It should be treated as part of integrated river control for all purposes

By Arthur E. Morgan

Chairman, Tennessee Valley Authority, Knoxville, Tennessee

ALMOST before the Ohio River's flood waters had swept on into the Mississippi last month, excited people were exhorting the government to build dams, to protect soil and plant forests, to do this or that in order to prevent future floods. Arthur E. Morgan faced the same confusion of demands two decades ago when after the disastrous Miami River flood of 1913 he was called on to safeguard the valley. As foremost authority in flood-control planning ENGINEERING NEWS-RECORD *has asked him to tell how floods should be dealt with. The present article is his response.*

—EDITOR.

WHEN we consider the hundreds of millions of dollars of direct loss due to a great flood like that of January, 1937, and the indirect losses of relief load, broken health, interrupted business, and loss of taxes, profits and other revenues which result, it seems probable that comprehensive and well-integrated plans for national flood control represent essential economy in our national life. The cost of failing to undertake the work probably would be greater than the cost of its orderly achievement.

Flood control on a national or regional scale represents design and planning of an unprecedented order of magnitude and complexity. Properly prepared for and wisely conceived and administered, as an inseparable part of integrated river control, it is one phase of our national life in which waste can be superseded by productive economy.

A pioneer problem

ON large river systems like the Ohio or the Mississippi great floods can result from excessive rainfall over a limited part of the drainage area. Successive great floods usually are caused by quite different distributions of rainfall. While we may be certain that maximum rainfall over all parts of a large river system never will occur at one time, yet the probable degree of approach to such a maximum cannot be foretold with any precision. American experience is too short to furnish conclusive guidance. In Europe and in China, where long-time records otherwise might be available, the conditions of most river channels have been so changed through the centuries that close comparisons cannot be made. On the Danube River near Vienna, where flood heights have been recorded and where a rocky channel has been unchanged, a flood in the year 1055 had a discharge about fifty per cent greater than the average greatest flood of a century.

On a system like the Mississippi or the Ohio the greatest flood of record, which on the Ohio occurred in January 1937, may be considerably exceeded when more of the tributaries experience approximately maximum rainfall at the same time. For several years before the Mississippi flood of 1927, in the annual reports of the authorities in charge of the river, confident official statements were made that the Mississippi was safely controlled against floods. The 1927 flood was an effective answer to those claims. Today there is a contrary tendency to pessimism in some quarters and an assumption that flood control on large streams is ultimately impossible. No such broad generalizations of pessimism are justified. Some large river systems can be completely controlled. In some cases it will be more in the public interest to remove improvements from the flood plain than to make the great public expenditures necessary to protect them.

The United States is a unique case of rapid development of a little known region. We have built large cities in our river valleys without knowledge of what the maximum flood conditions are on those rivers. On our smaller rivers, tragic flood experiences, like those at Dayton, Ohio, Pueblo, Colorado, and Montpelier, Vermont, will occur from time to time, until flood control becomes effective. Engineering analysis can predict where such disasters are certain to occur, and in most cases can prevent them by adequate construction.

By an intelligent and consistent program loss from floods can be reduced to a very small part of that now experienced, and in some cases collateral benefits will contribute substantially toward paying the cost. Because of the great extent of our largest river systems, and because of the extreme flood conditions to which they are subject, the mastery of the flood problem on American rivers would be an achievement without precedent of its kind in human history.

Old analyses must be discarded

ARE we prepared to undertake this huge task? Consider that the forty years during which the automobile has revolutionized personal transportation and vitally affected many phases of living have witnessed a no less revolutionary development of construction equipment and materials. By the influence of this change, with the advance of engineering knowledge and skill, projects which at the beginning of the century were only in the range of fantasy are now entirely feasible. Old anaylses of flood-control problems must therefore be discarded, and each important flood-control project must be given a fundamentally new and fresh analysis, almost as though it never before had been approached.

In engineering as in most other fields, the habit of carrying over old solutions into new situations is a handicap to effective achievement. One of the great changes in flood-control engineering of the present and immediate future is in the dimensions of individual works undertaken. A flood storage reservoir of twenty-five million acre feet, with the elimination of a county or two in its creation, may not prove impracticable. Among the conditions of flood control on a nation-wide scale, therefore, will be (1) completely new and fresh analyses of old situations, on the assumption that old conclusions may no longer be valid, and (2) the habit of thinking and working in far larger dimensions.

Examine every possible solution

ANOTHER fundamental principle in a widespread flood-control program is rigorous adherence to the policy of thorough examination of every possible method of solution, including those which seem to offer very little promise. One of the greatest practical weaknesses

of engineering design, in the field of flood control as elsewhere, is the tendency to assume that less obvious or less promising solutions can be passed by without being analyzed to the point of absolute assurance that they are or are not feasible.

The habit of thoroughgoing comparison of all possibilities should be associated with the habit of restless, imaginative inquiry which persists in becoming aware of every possible method and combination of methods, and which insists, also on ferreting out all facts and conditions that might have a bearing on solutions. Lack of these obvious habits, rather than technical limitations, are the chief handicaps to a high order of engineering design in this field.

At the beginning of the Miami River flood-control studies in Ohio it was generally considered that levees offered the only practical form of flood control, and I was largely of the same conviction. The authoritative expressions of engineers experienced in flood control were taken for granted when they held that reservoirs were not feasible for such purposes. I had expressed my disbelief in reservoir flood control to the flood prevention committee at Dayton. The possibility of control by dams was examined simply to carry out the sound engineering policy of investigating every possibility, no matter how remote. When the evidence forced me to change my views, no one was more surprised than I.

At the beginning of that project probably none of the men in a large engineering force believed definitely in the possibility of flood control by dams. At the end everyone was convinced. Yet, while dams formed one of the outstanding elements of that flood-control plan, a very considerable part of the program was of channel control and levees.

No single remedy

ONLY rarely in any large flood-control project will a solution be found to consist of any single type of construction. Seldom can a flood-control project be mastered best by levees alone, or channel improvement alone, or spillways alone, or floodways alone, or reservoirs alone, or simply by removing buildings and other improvements from flooded areas. Quite generally the question to be answered is not which of these methods to apply, but how much of each. Too often such proportioning is arrived at by hunch or intuition, or by a few cut-and-try approximations. Where large expenditures are involved nothing short of conclusive analysis to arrive at ultimate economy and value in proportioning the various elements is adequate. A logical method for such analysis was described by E. W. Lane and S. M. Woodward in Part VII of the Miami Conservancy Technical Bulletins, which was entitled "Hydraulics of the Miami Flood Control Project."

Now as always the public is receiving the impression that choice of loyalties must be made between certain conspicuous alternatives, somewhat as a man might be called upon to decide whether to be a communist or a fascist. At present Congress is under pressure to support those who promote levees for the main stem of the Mississippi and those who would serve the ends of flood control by controlling "little waters" at the sources of streams. There is danger that Congress may appropriate vast sums committed to specific methods of flood relief before conclusions are reached based on complete and thorough analysis of all the factors.

For many years past I have vigorously protested against a program of "levees only," yet I am equally persuaded that some of the propaganda for control of great floods on large streams by works on the small tributaries has been superficial and unsound. I would not outlaw any method, but only would insist that each take its place without prejudice or preference as the subject of impartial analysis. If that is done, honest and open-minded engineering can be trusted as to the results. In a field so affected by preference and tradition as is that of flood control, even experienced engineers sometimes have difficulty in freeing themselves from unconscious assumptions.

In many fields of engineering the necessary data are general and universally applicable. For instance, with minor adjustments a steel building can be designed in the same way for Denver or New York. In flood control, on the other hand, an exceptionally large part of the controlling conditions are peculiar to the individual project. Rainfall, run-off, stream capacities, storage areas, dam and levee foundations, materials of construction, resulting damages—all these must be separately determined for each undertaking. In few types of engineering are there so many unstandardized factors.

It follows that the procuring of basic data is vital to dependable and economical flood control. When a catastrophe occurs there is a great burst of public interest, followed, perhaps, by large appropriations of public funds. Yet frequently when engineers come to direct the expenditure of that money they find that they need data which can be secured only through years of patient work with moderate appropriations. Because much of this data can be acquired only through long periods, an intelligent national flood-control policy must include adequate year by year provision for the Water Resources Branch of the U. S. Geological Survey, the U. S. Weather Bureau, and other federal agencies. Such support is one of the surest ways to promote the economical and effective expenditure of public funds in river control.

Integrated river control

FOR flood control to take its proper place in our national development, it must be seen as part of a program of integrated river control for all purposes. To carry through one project for flood control alone, another for navigation alone, another for power development alone, another solely to correct stream pollution, and another for recreation alone, almost surely will cause waste and overlapping. It is not always necessary that all these and similar purposes be carried to fruition in each development, but it is important that they all should be kept in mind, that conflict and duplication be avoided, and that to the greatest degree which is feasible the best total of benefits should be achieved.

ARTHUR E. MORGAN ON FLOOD CONTROL.

✦ Comprehensive and well integrated plans for flood control represent essential economy in our national life.

✦ Control of great floods is a task of unprecedented magnitude and complexity. We have built large cities in our river valleys without knowledge of what the maximum flood conditions are.

✦ Old analyses of flood-control problems must be discarded. The habit of carrying over old solutions into new situations is a handicap to effective achievement.

✦ A fundamental principle is thorough examination of every possible method of solution.

✦ At the beginning of the Miami project none believed definitely in the possibility of flood control by dams. At the end everyone was convinced.

✦ Seldom can a flood-control project be mastered best by levees alone or reservoirs alone, or simply by removing buildings. The question to be answered is not which method to apply, but how much of each.

✦ The procuring of basic data is vital.

✦ Flood control must be seen as part of a program of integrated river control for all purposes.

✦ There is popular over-expectation as to the possibilities of power development associated with flood control. Yet each project should be worked out on its merits.

✦ Soil management, forestry and headwater reservoirs should not be ignored.

✦ The need for over-all coordination is beginning to emerge.

✦ Creativeness should be kept in dominant position even at some loss of superficial order and efficiency.

it would be a mistake arbitrarily to eliminate any type of benefit from river-control developments. Some bills before Congress would prohibit power development at reservoir dams. There is popular over-expectation as to the possibilities of power development associated with flood control in the eastern United States. Few eastern rivers are so favorable in that respect as the Tennessee, and the possibilities on that river system fall far short of those on the Pacific Coast. Moreover, flood control and power in some cases are mutually exclusive. Yet each project should be worked out on its merits, and power development should not be sacrificed where it proves to be a normal and profitable element in unified river control.

Soil protection and small reservoirs

IN my opinion there recently has been exaggeration of the possibilities of flood control by soil management, forestry, and the construction of reservoirs on very small headwater streams. Yet these types of development should not be ignored. The prevention of soil erosion is a great issue and will have an influence on the filling up of at least the smaller reservoirs, while general soil management can have a very important part in our national economy. Soil and forest cover doubtless mitigates small and local flood damage. Small reservoirs often are valuable to control local floods, to dilute stream pollution, to regularize streamflow, for industrial water supply, and for recreation. In the South, on the other hand, they may greatly increase the menace of malaria. They should be treated on their merits, and not be supported or opposed because of their promotion by an emotional cult.

Not only is it necessary for any particular river system, such as the Tennessee or the Ohio, that there shall be an integrated program of river control, but the interrelations of tributary systems should be coordinated, so that a plan and program shall emerge for the most inclusive river system, which in that case is the Mississippi. Storage on the Tennessee or the Ohio or the Arkansas affects the necessary size of levees on the main Mississippi River, and may affect the amount of storage necessary or economical on other tributary systems. This need for over-all coordination is beginning to emerge clearly in our national consciousness.

Importance of creativeness

THE assembling and integration of all elements of preparation and administration for river control into an effective working program and organization is a greater undertaking in a large river control project than in many other phases of engineering. In such administration it is important that inventive and creative engineering ability shall not be subordinated to administration regimentation.

An engineering organization can be so subdivided and departmentalized that each engineering unit is doing an unrelated part of the job, and the head of the organization may be assembling and organizing, rather than creating and synthesizing. I believe this tendency is one of the reasons why a large engineering organization often tends to standardize conventional solutions, rather than to recognize and accept the creative originality which may exist in its ranks. Creativeness should be kept in dominant position, even at some loss of superficial order and efficiency.

On public work it also is imperative that personnel be chosen on the basis of merit only, and not for political reasons. Otherwise there will be a great loss of effectiveness.

* * *

These remarks have dealt only with general conditions for developing and administering a river control plan, and not with specific methods of flood control. Frequently it is failure in actual practice to meet these general conditions which has prevented the highest quality of results in such undertakings. It is my experience that, if these general conditions are met, wise solution of specific problems will be a normal outcome.

Exterior Walls of Concrete House Completed in One Day

Use of vacuum process by which excess water is speedily forced out of freshly poured concrete permits quick removal of forms followed by application of a stucco surface before final set has occurred

POSSIBILITIES of accelerating concrete house construction through the use of the vacuum process for removing excess water, thus permitting the prompt removal of forms, were demonstrated two weeks ago at Bethesda, Maryland, when the exterior walls for a 27 x 37 ft. bungalow, consisting of two 3-in. slabs separated by a 6-in. air space, were completely poured, the forms removed and the exterior finish coat applied in one working day. The possibility of using building paper as a form material and of applying a monolithic stucco finish to concrete walls were important corollaries of the demonstration.

The construction process involved connecting pumps to the wall forms and subjecting the fresh concrete to a vacuum so that the atmospheric pressure against the forms forced out the excess water. When the forms were stripped the green concrete thus revealed was

FIG. 1—DEPOSITING CONCRETE in wall forms equipped with vacuum cups to remove the excess water on a house near Washington, D. C.

FIG. 2—FORMS consist of a building paper inclosure for the center air space and exterior panels of plywood supported by vertical I-beams. At left the complete form and at right the form under construction, showing the interior facing of mesh cloth and the rubber seal strips on two of the plywood form panels. In this view the building paper form and the wire mesh reinforcing are in place.

FIG. 3—TEXTURE of wall surface when forms were removed and before finish coat was applied.

firm and compact, with ample strength to retain its shape, even in the thin vertical slabs. Special form linings of cloth and panel seals of thin rubber prevent the loss of any appreciable amount of cement from the mix. This vacuum process has been used previously in a number of experimental installations among which were laboratory tests at Yale University on road slabs and building columns (ENR, Dec. 19, 1935, p. 867) the laying of a short section of deck slab on the Queensboro Bridge at New York (ENR Oct. 15, 1936, p. 563), placing of short sections of road slab for the New York and Pennsylvania state highway departments, and the resurfacing of dam faces, bridge piers and weathered roads in Rhode Island and Massachusetts.

The day's operations at Bethesda started with the concrete foundation complete, rough flooring in place and wall forms erected. The total thickness of the walls including the 6-in. center air space is 12 in., and the necessary forms consisted of plywood panels for the exposed faces set 12 in. apart and enclosing a center form for the air space consisting of building paper attached to wood studs. The use of building paper was possible since the 3-in. thickness of concrete in each slab was poured in lifts of only about 3 ft. before the vacuum was applied; as soon as the concrete was under a vacuum the forms were pushed in against it by the outside air pressure and literally were supported by this pressure.

The plywood exterior forms were built in 4 x8-ft. panels and lined with a coarse mesh cloth to permit uniform suction over the entire face from single suction cups and also to provide a passageway for the water that is forced out of the concrete. Thin strips of rubber along the edges of the panels served as seals and to close the cracks between the panels. Two similar rubber strips placed horizontally divided the panel into three suction areas corresponding to the lifts of concrete. By applying the vacuum to the wall progressively in three lifts the hydrostatic pressure on the forms at any time was reduced to that on one of the lifts since the water was largely removed before the next lift was placed. Application of the vacuum was accomplished so rapidly, however, that pouring of the wall was practically a continuous operation.

Forms were erected by first building the interior box of building paper. Wire mesh was then hung on both faces of this box and in addition galvanized bolts were pushed through it on 3-ft. centers both ways; the protruding ends of these bolts equipped with nuts, upon being buried in the concrete, served as ties between the two 3-in. slabs comprising the walls. Finally, the plywood exterior wall panels were set up. Light steel I-beams placed vertically supported the form panels at each edge, the inner and outer beams being connected at the top by turnbuckles and at the bottom by a removable bolt passed through the wall.

Truck-mounted mixers furnished the concrete which had about a 7-in. slump. Wheeled to the forms in buggies the concrete was dumped into two-spout hoppers that delivered it to both wall slabs simultaneously. Electric vibrators were used on the plywood forms to assist in the placing operations. As each 3-ft. lift was completed vacuum was applied through pipes and flexible hose connecting to a cup on the panel face as shown in Fig. 1.

Pouring of the first half of the house, begun about 11 a.m., was completed at 1 p.m., and the first form panel was removed by 2:15 p.m. The surface of the fresh concrete was hard and firm, with an even texture reproducing the details of the corrugated rubber seal strips and the mesh lining. A workman walked across the upper exposed edge of the fresh slab without causing any perceptible flaking or chipping.

At 2:45 p.m. masons started to apply a ¼-in. surface coat, made up of one part white cement and two parts of white sand, to the exterior of the walls. Although the walls at that time were hard, final set of the cement had not occurred, so that it is claimed surface and wall are truly monolithic. The ability to obtain such monolithic surfaces is set forth as a prime advantage of the vacuum concrete process not only in residence construction but for retaining walls and bridge surfaces in general.

At the close of the afternoon the entire wall had been poured, the forms stripped, and the exterior wall coating applied. The demonstration house was built by K. P. Billner, president, Vacuum Concrete Corp., New York, N. Y.

Ice Dam at Grand Coulee Stops New Slide

The ice dam built at Grand Coulee by contractors to prevent earth slides into an excavation again demonstrated its value on March 1 by holding back a fresh slide.

The small slide moved a considerable distance in the area southeast of the ice dam and kept moving until it struck the nearly flat area directly behind the ice barrier and there halted. The slide caused little damage except for covering one minor construction road.

Fighting Subgrade Swelling On Kansas Roads

Cause of swelling isolated by laboratory tests—Remedy found in new methods of fill compaction and subgrade stabilization—Experimental road constructed for more exhaustive investigations

FIELD PRACTICE, *described by*.....HAROLD ALLEN, *Engineer of Materials*
RESEARCH WORK, *outlined by*.....H. D. BARNES, *State Highway Engineer*
LAWRENCE TEST ROAD, *by*.....H. D. BARNES and HAROLD ALLEN

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CONFRONTED several years ago with the problem of concrete pavement heaving, the Kansas highway department began an investigation to determine methods of prevention. Few studies of pavement trouble have been more continuous or have developed more successful advances in construction practice. While it appeared from the first that the trouble was caused by swelling soil and attention was centered on soil character and behavior in the wide research and experimentation that followed, other possible contributing causes were not overlooked.

This investigation and the definite results obtained are the subjects of the first of the following articles. The moisture treatment indicated by the laboratory studies and the method of applying it in fill and subgrade compaction is described in the second article. The final article is a description of the Lawrence experimental road and its extensive equipment for observing and recording pavement structure and subgrade action. The articles by Mr. Allen are parts of a report by him to the recent highway conference of the University of Colorado. —EDITOR

Absorptive Soils Cause Heaving

By H. D. Barnes

CONCRETE PAVEMENT SLABS distorted at the ends so as to produce high joints first appeared in Kansas in 1928. The investigation of warping was quite meager until 1931 when it became apparent that a relation existed between the type of subgrade soil and the distortion of pavements. The pavements observed showed distortions varying from negligible movement to as much as 2 in. These distortions could not be associated with any one locality or climatical condition. Some badly distorted slabs displayed no visible transverse cracking on the surface of the pavement, but it was found by trenching along the edge that cracking had developed through part of the depth of the slab from the bottom up. It was of note that a small bottom crack was accompanied by lack of contact between the pavement and the subgrade over an appreciable area.

A large number of soil tests were made in 1931 and 1932 in an endeavor to determine the cause of warping. The results indicated that these subgrade soils possessed characteristics that closely approached or fell within the A7 group in the Bureau of Public Roads classification. The next step was to study the actual action of these subgrade soils when subjected to different conditions of moisture and compaction. A series of tests in the laboratory of soils having a moisture content and degree of compaction similar to those found in the field showed a volume change from absorbed water sufficient in magnitude and force to cause the observed distortion.

The soil studies were supplemented with special tests each designed to answer special questions brought up in the interpretation of data as regular studies progressed or further to test the validity of certain data. These special tests consisted of (1) the construction of an experimental test slab in the laboratory in an attempt to duplicate field distortions; (2) straightening distorted pavement slabs by the addition of water to the subgrade (*ENR*, Oct. 11, 1934); (3) laboratory and field tests to determine the swell of soils; (4) field tests on undisturbed columns of soils; (5) laboratory tests to determine the expansive force of a soil and (6) the Lawrence experimental test road.

Throughout the investigation, every effort was made to determine whether or not the quality or the composition of the concrete was in any way associated with distortion. The aggregate used revealed no unsoundness under freezing and thawing. The distortions occurred on concrete composed of aggregates of flint gravel and also sand gravel, all of which have been used on other projects where no distortions have developed.

Various types of corrective measures were initiated in current construction projects with little or no significant beneficial results. These special treatments included selected blanket subgrade courses, numerous types of joint drains, a variety of different joints, etc.

Tests develop cause

Research in the field and laboratory has shown that high joints or warping is due largely, if not wholly, to the swelling action of some soils resulting from the absorption of water from leaky joints and along the edges of the slab. The subgrades associated with distortions were found to be expansive soils of the A4, A6 and A7 groups. (Fig. 2) The results indicate that the amount of swell is dependent upon the characteristics of the soil itself as shown by the

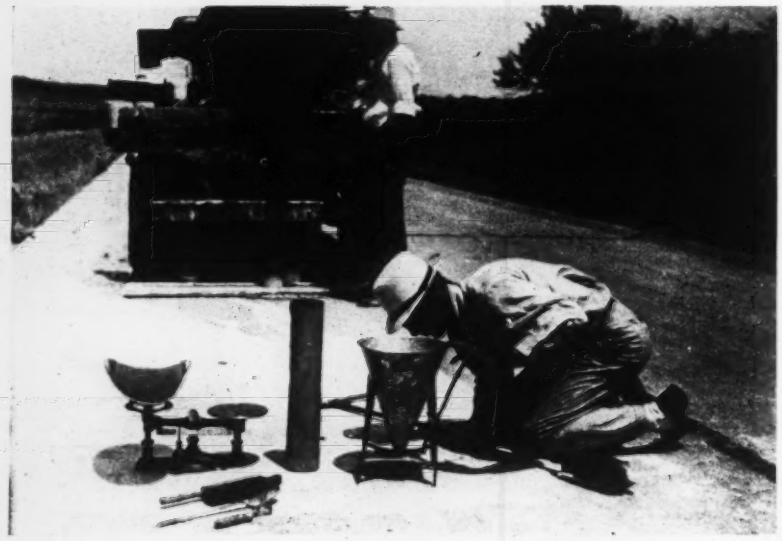


FIG. 1—CORE DRILLING TRUCK and part of the field equipment used in subgrade soil study on Kansas roads.

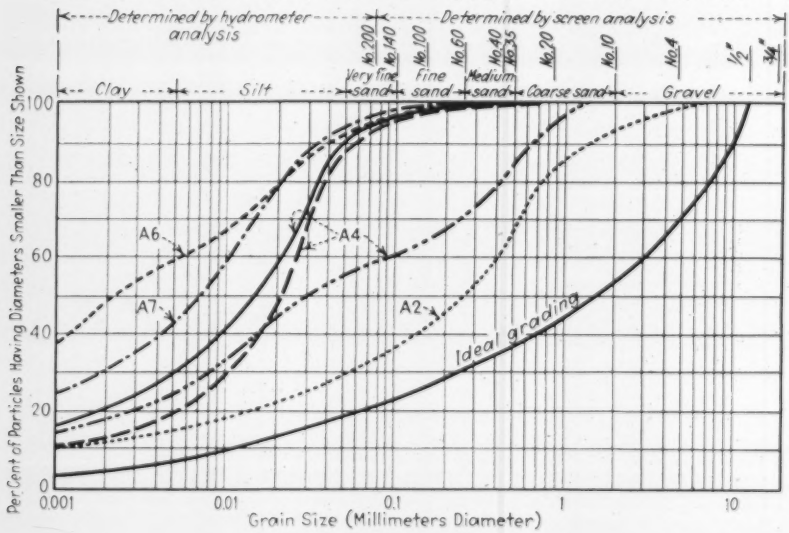
test constants; upon the structural arrangements of the soil in its natural state, and upon the compaction and moisture content.

To emphasize, the presence or absence of distortion was found to be definitely associated with characteristics of the subgrade soil and the *moisture distribution* in the subgrade. Distortions were not found to occur on sand and gravel subgrades of the A3 group; on sandy loams of the A1 group; on some of the more sandy soils of the A2 group; on some of the sandy loams and less plastic silts of the A4 group, or upon *plastic soils containing moisture equal to the plastic limit* uniformly distributed under the pavement. All of the soils upon which distortions were found were of a cohesive nature, being plastic when wet; all were expansive loams of the A4 group and silty clays and clays of the A6 and A7 groups. The most severe distortions have been found on the border line clay loams—that is, soils whose test constants fall near the dividing line between the A4 and the A6 or the A7 groups.

The amount of swell which results from the absorption of water by the soil is dependent upon: (1) the physical characteristics of the soil; (2) the moisture content and density of the soil at the time of concreting, and (3) the amount of water available for absorption at joints and along the edges of the pavement.

The most durable conditions as it is related to most subgrades, is the maximum density obtainable with heavy duty sheepsfoot rollers with the soil voids at that density filled with water. Soils having moisture contents during compaction sufficient to result in condition of maximum density with the pore spaces as nearly as possible filled with water after compaction offer greater resistance to the gain of water by absorption or the loss of water by evaporation than do soils compacted to any other condition.

FIG. 2—GRAIN SIZE ANALYSIS of Kansas subgrade soils found to cause pavement warp; these soils fall in the A 2, 4, 6 and 7 groups of the B.P.R. classification.



Lessons practically applied

Moisture treatment of the soils under slab was first begun during the construction season of 1934. To date no severe distortions have occurred on projects where the moisture content of

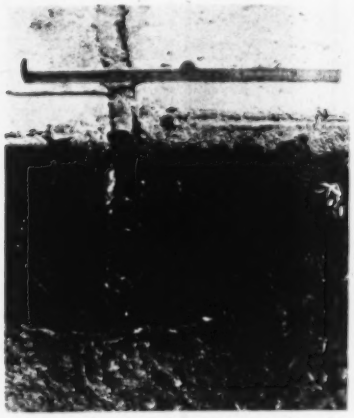


FIG. 3—A TYPICAL JOINT FAULT, one slab end pushed up higher than the other, in a pavement on a swelling subgrade.

the subgrade has been made equal to or in excess of the lower plastic limit of the soil.

Detailed soil surveys are now made at the time of the plans survey on all principal locations. Exceptions are made on locations in the western part of the state where the land is flat and the soil uniform. The surveys consist of boring out, sampling and identifying the soils in the profile; locating the most desirable borrow materials; suggesting means for stabilizing sands; removal or special handling of unstable or undesirable soils; correction of unstable or undesirable soils; correction of unstable embankment foundations; location of drains to care for drainage of sub-surface water; treatment of points where the grade line intersects the ground line; placing soils in the fill; determining the size of channels which will result in scour for various soils and conditions, and treatment of ditches. Recommendations are then correlated with design features and incorporated in construction details.

On all new grades on which moisture treatment and compaction is specified, recent specifications require both moisture content and density control in the top 4 ft. of the fill, and density control in the remaining part of the fill. In

general, the stability and permanence of the base is now subject to as strict inspection on the foregoing principles as other component parts of the structure. A manual, including the laboratory tests necessary for classification and identification of soils, the methods of applying the data obtained to classification, and the details of field tests and procedure for obtaining satisfactory results on construction, is provided for the use of all field engineers.

Field Method of Stabilization

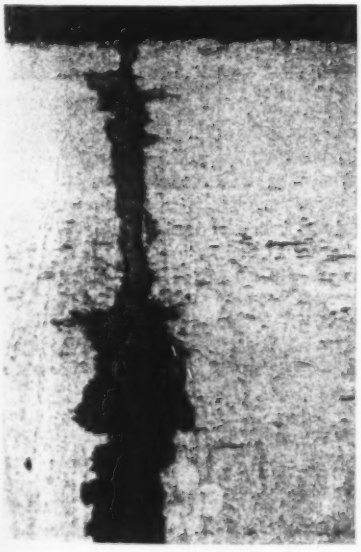
By Harold Allen

BASED on the experimental determinations described in the preceding article the following field procedure of base stabilization is employed. The soil data furnished in the soils survey is first studied by the engineer in charge and from this he is able to ascertain the number of compaction curves and such further data as he may need for the actual construction of the project. A compaction curve is made up in the field laboratory for each type of soil which will be encountered during construction that the earthwork curve are obtained by carefully drying the soil, adding increments of moisture and compacting the moistened soil in a standard compaction mold with an especially designed tamper. Very definite instructions are given for the procedure in this work so that the results obtained will be uniform.

The density of the compacted material is obtained and a curve is plotted showing the relation between the density and the moisture content. The resulting curve gives information as to the optimum moisture content and the maximum density obtainable at that moisture content. It is then required during construction that the earthwork be compacted to 90 per cent of the density indicated on the curve. As the work proceeds the density of the soil in the embankment is determined by means of special field apparatus and procedure described in the soil manual. The method consists essentially of determining specific gravity of undisturbed soil samples.

This work is carried on by the regular forces of the resident engineer on each project. A field soils engineer is sent to the project to instruct inspectors in the work and the work is carried on under his supervision. The additional expense of making tests and carry on the work is very little as compared to the value of the results obtained.

FIG. 4—A TYPICAL LEAKY JOINT; the dark areas show the water squashed out by a passing automobile two hours after a rain.



Construction methods

The general construction procedure is best indicated by the following clauses taken from the standard specifications:

Standard Compaction Test—This test is designed to determine the moisture content at which maximum compaction is obtained, and to determine the density (dry weight per unit volume) which is obtained at that moisture content when a soil is compacted in three layers in a mold 4 in. in diameter and having a volume of 1/30 cu.ft. by applying 25 blows on each layer by means of a specially constructed hammer having a 2 in. diameter face, and delivering a blow to the soil equivalent to that of the drop of a 5½ lb. hammer through a space of 18 in. When the plastic index of the soil is greater than 25 (heavy clays) the soil is placed in the mold in four layers. The maximum density obtained in this test is designated as the Standard Compaction of a soil.

Placing Fill—All material to be compacted is bladed into layers of uniform thickness prior to rolling. When the embankment material is of a cloddy nature and rollers other than the tamping type are used, large clods and lumps of earth are broken down by discing or harrowing.

Roller Requirements — Power rollers weigh not less than 10 tons and provide a compression on the rear wheels not less than 300 lb. per lin. in. of tire width. Tamping or sheepsfoot rollers consist of metal rollers, drums or shells surmounted by metal studs with tamping feet projecting not less than 7 in. from the surface of the roller drum or shell. Tamping feet are spaced not less than 6 in. measured from center to center in any direction, and the cross-sectional area of each tamper foot, measured perpendicularly to the axis of the stud, is not less than 4 nor more than 12 sq. in. The weight of tamping rollers is such that when fully loaded the load on each tamper foot is not less than 95 lb. per sq.in. of cross-sectional area. The load per tamper foot is determined by dividing the total weight of the roller (loaded) by the number of tamper feet in one row parallel to the axis of the roller.

The contractor is required to level up each successive lift or layer and make a sufficient number of trips with the roller over the entire surface to insure that all soils are uniformly compacted to a density equal to or greater than 90 per cent of standard compaction for each soil at the moisture content specified. Each successive lift is to contain only that amount of

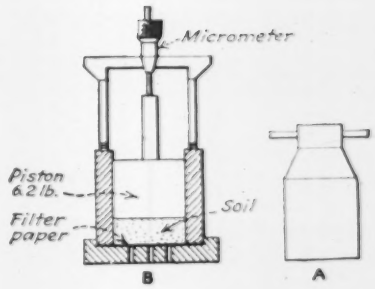


FIG. 6—THE VITAL WEAPON of the field engineer in combatting swelling subgrades. In operating it a quantity of soil is thoroughly mixed with sufficient water to result in a predetermined moisture content. The soil is subjected to a predetermined pressure in mold B (4 in dia.) with the piston A. Sufficient soil is used to result in a 2 in. pat. During the test the pat is subjected to a constant pressure equivalent to that of a concrete pavement. An initial reading is taken with the micrometer, the mold is placed in a pan of water and the soil pat is allowed to absorb water through the bottom of the mold. Additional micrometer readings are taken at regular intervals to determine swell.

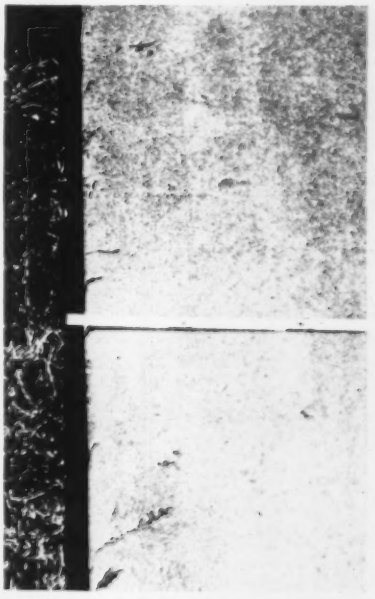


FIG. 5—A SHOULDER that pulled away from the pavement because of soil shrinkage during the dry season of 1934.

earthy material which will insure sufficient and uniform compaction, but in no instances is any lift or layer to exceed 6 in. of compacted earth.

Moisture Content Requirements—When the height of the embankment is 4 ft. or less and the moisture content less than that necessary to obtain maximum density as determined by the standard compaction test, an amount of moisture equal to or in excess of that necessary to obtain the maximum density as shown by the test is added; when the height of the fill is greater than 4 ft. the moisture content for that part of the fill more than 4 ft. below grade is to be the amount necessary to obtain 90 per cent or more of standard compaction, and the moisture content in the top 4 ft. of the embankment shall meet all requirements of an embankment 4 ft. or less in height. When the moisture is added it is to be thoroughly and uniformly mixed with the soil before it is rolled or tamped. The mixing is to be accomplished by means of spring tooth harrows, disc harrows, one-way disc plows, or other equipment and methods approved by the engineer.

The outstanding facts to be noted are: (1) All fill is constructed in rolled layers and (2) moisture provision is made an essential element of fill compaction.

Verification Sought From Test Road

By H. D. Barnes and Harold Allen

TO VERIFY the above findings and practices described and to determine other causes for the warping of concrete pavement, an experimental road was designed in which the subgrade was specially prepared and on which careful observations could be made of the rate of change in the shape of the pavement. Since there were several other problems in concrete paving construction and design which were worthy of study, these were also included in the project. The site chosen was five miles on state highway No. 10, east of Lawrence, Kan.

Actual construction was started on July 22, 1935, and the road was completed on Aug. 21, 1936. The road was divided into 20 sections. These sections varied in length from 600 to 3,400 feet., the longer sections being divided into subsections. The slab of the entire project was a 9:7:9 in. cross section on a 20-ft. width.

Purposes in mind

The purpose of the test road is to determine the warping of concrete pavements constructed on a saturated subgrade; on an extremely dry subgrade; when no expansion joints are used; when constructed on a subgrade composed of soil having small volume change, and when constructed with an asphalt membrane between the bottom of the slab and the subgrade; to determine the effect of portland cement an admixture in the subgrade to prevent the warping of concrete pavements; the effect of open joints in concrete pavements constructed on a saturated subgrade or on a dry subgrade; effect of sprinkling a dry subgrade, to the point of maximum saturation, prior to the construction of the pavement; the variation in volume change for concrete composed of different types of aggregates and different water-cement ratios; the effect of delayed vibration and finishing of concrete; the merits of different types of expansion and contraction joints; the relative merits of the Johnson method of placing and finishing concrete, and the friction between pavement and subgrade.

The measuring devices

Sealed inspection boxes are located in the pavement on all sections so that the subgrade may be observed and soil samples taken at such periods as may be necessary.

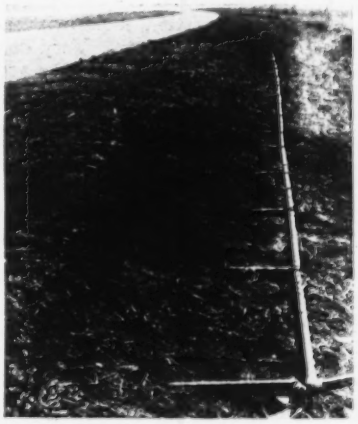
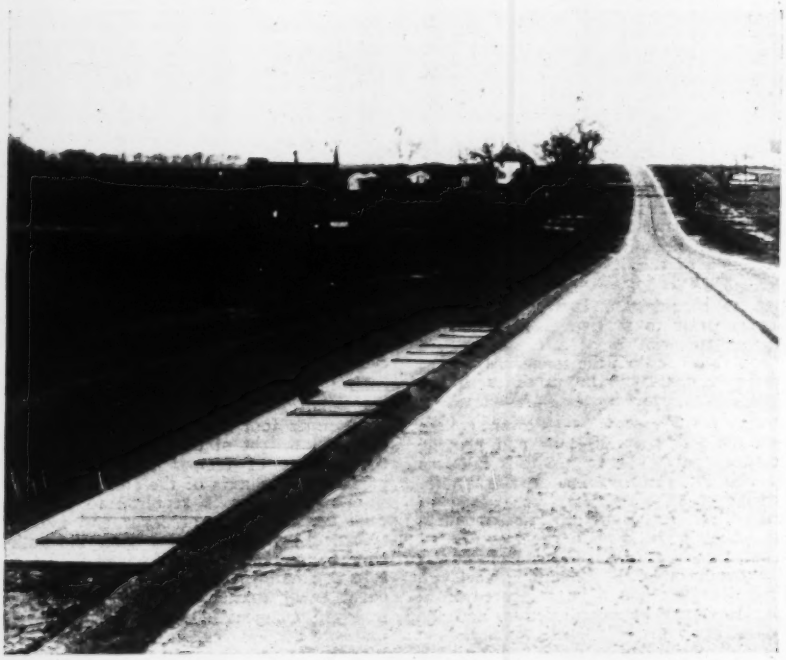


FIG. 8—FORCING WATER into the subgrade under old pavement where the subgrade has dried out and shrunk away from the pavement has successfully restored the contact.

Provision is made for the measurement of subgrade friction by constructing pavement so that two 25-ton jacks (one on each side of the pavement) can be used to move the pavement and provision has also been made to take measurements with Ames dials at various points of the slab which will give the movement for each increment of load.

Strain gages are provided that will give the amount of any volume change of concrete and another device measures the change in length of a slab by actual measurement. In connection with the device for the measurement of the change in length, provision has been made for measuring the vertical position with reference to a fixed point.

FIG. 9—EXPERIMENTAL ROAD near Lawrence, Kan., showing location of some of the recording and observation devices for measuring pavement and subgrade action.



Goldbeck pressure cells are installed at expansion joints at various points to measure the change in pressure between the slab and the subgrade due to any volume changes in the soil or to any other factor which may cause such a change in pressure.

Recording thermometers are installed in convenient inspection boxes which provide data on temperatures in the top, center and lower part of the slab and at a point 6 in. below the top of the subgrade. A recording humidigraph and a barometer are installed on the project, and also rain gages set at various positions throughout the length of the road, and precise levels are taken at periodic intervals.

Fig. 9 shows a battery of inspection boxes installed on a portion of the road in the center of the right lane for observing and sampling the subgrade. The covers are sealed with asphalt after each inspection. It is intended that readings will be taken over a period of two to three years. Considering the recent completion of the project, it is obvious that no significant data have at this time been correlated with the various field conditions.

Practical Soil Mechanics For Small Dams

Grain-size analysis, Proctor density test, compaction with sheepsfoot-rollers and California section advantageously employed

By Denzil Doggett

Assistant State Engineer, Department of Conservation, Indianapolis, Ind.

IN BUILDING some 30 small earth dams since 1928, the Indiana Department of Conservation has passed through an evolution in design and construction to practice representing the latest development of science in the disposition of materials and in fill compaction. In their application to very small dam-building these processes, it is believed, have a special interest, and an outline of practice is given here with a brief account of the character and purpose of these water conservation projects.

Relief money speeds work

The reservoirs are small (exclusive of marsh areas the average water area is 25 acres) some of them cover only an acre or two and the largest covers 170 acres if one 500-acre marsh area is excluded. They are located in state forests, parks and game preserves, generally in former waterless areas or those which have only intermittent streams. The purposes of course are various: To attract game birds, for fish propagation, for irrigating forest nurseries, for fire fighting and for recreational purposes.

At first the progress was slow: Two small lakes were created at Clark County State Forest for irrigation purposes in 1928 and 1930. A reservoir for watering game birds and animals was built at Brown County Game Preserve in 1930 and the lake and bathing beach at Shakamak State Park in 1931. A dam for impounding water for the swimming pool at Brown County State Park was built in 1932. With the advent of the relief program, utilizing labor on public lands, many dams were authorized and have been constructed. Many have been built by the labor of the allied relief organizations, CWA, FERA, and WPA. Others have been started by these organizations and completed by the CCC doing emergency conservation work. Still others have been completed in their entirety by the ECW organization.

In the earlier days of construction, lack of funds precluded the use of the proper rollers and scientific tests, as well as power equipment for excavation. This was under CWA and to a minor degree, its successors. Now that the relief load has been lessened, equipment again takes up the work and hurries the job to completion. Accordingly, the methods of handling earth have been progressively, men with picks, shovels and wheel-barrows; men with picks, shovels and horse-drawn wagons or slip scrapers; men with picks, shovels, trucks and tractor-drawn rotary scrapers, and men with power shovels and trucks or tractor-drawn scrapers of the Le Tourneau type. In like manner, the methods of compaction have been progressively, men with tamping bars; teams and wagons; tractor-drawn smooth rollers, and tractor-drawn sheepsfoot rollers.

A design evolves

Sound engineering design procedure was followed at all times. A thorough preliminary investigation was always made before the design was calculated and the plans were started.

The field work was necessarily first. A topographic survey was made of the lake site as well as the dam site. Test pits were then sunk at the dam site, carried down by hand to an impervious material. Borings, using hand machinery such as churn drills, earth augers and spring drills were made but the results obtained by their use were found to be less reliable than those from the pits. Logs of the materials encountered in the pits were prepared by the field party which usually came from the CCC camp on the property. The topographical maps and the cross-section of the valley at the center line of the proposed dam were likewise prepared by this same organization and all were sent to the central engineering office at Indianapolis. The materials at the proposed dam site and borrow pits were carefully examined by a civil engineer charged with that duty. In early structures, no mechanical analysis was made of borrow, due to lack of personnel. In addition, a geological survey was made of the area, including the dam site and borrow pits, by a representative of the Division of Geology. The survey notes of the engineers and the geologist were than brought to the central office where the dam and its appurtenances were designed.

The first dam built at Clark County State Forest was earth fill with a concrete core wall having a concrete gravity or overflow type of spillway. A shear gate drain was provided for lowering the level of the pond should occasion demand. The next dam built there was the same type except that the spillway was a concrete entrance weir leading to a 36-in. corrugated metal pipe which carried the water from the cut-off wall to the outer edge of the dam. This weir was located at such an elevation that 12 to 14 in. of water on the crest would fill the pipe. It was supported by concrete pillars located on the upstream side of the cut-off wall.

The first dam at Brown County Game Preserve was of earth with a concrete apron on the upstream side. An open

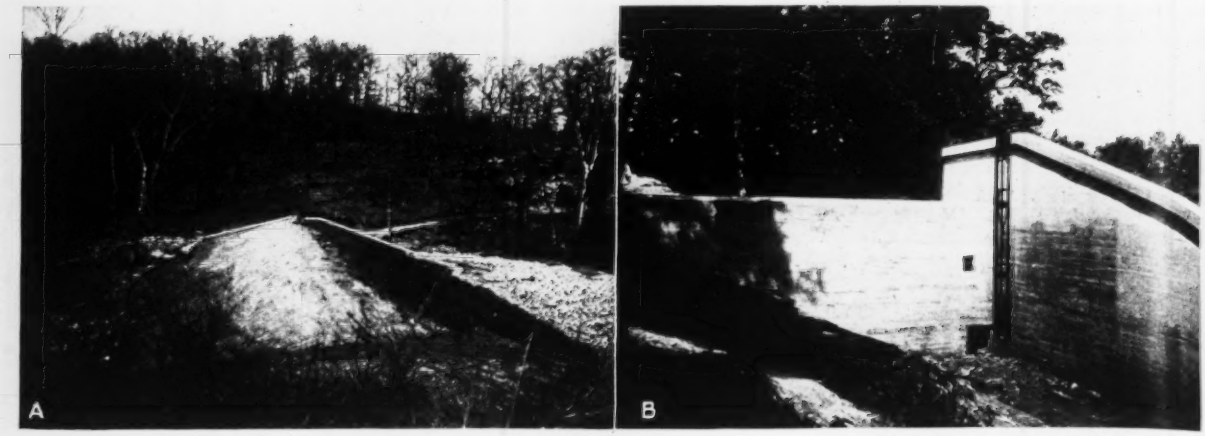


FIG. 1—EMBANKMENT and spillway of the Spring Mill Dam forming a lake of 28 acres in the state park of the same name.

concrete box side-hill spillway was provided at one end. A slack-line cableway was used in placing the earth. The first dam of all-earth construction was that at Shakamak State Park which utilized an abandoned railroad fill as the barrier. The concrete box culvert under the fill was blocked by three concrete cut-off walls which carry an 18-in. cast iron drain pipe and valve. The spillway consisted of a concrete weir structure, the floor of which sloped to a 5-ft. corrugated metal pipe. This pipe was jacked through the fill and the concrete structure built around the upstream end.

The next dam to be designed was that built in 1933-34 by the CCC camp at Lincoln State Park, near Lincoln City. In this design, previous experience was joined with that of civil engineers on comparable works a few years earlier in California. This resulted in the present design of an all-earth dam, using selected, impervious clay for the upstream third of the dam and selected materials, not necessarily impervious, for the downstream two-thirds. A cut-off trench to an impervious stratum was provided at the downstream limit of the impervious section of the dam and was filled with the same impervious material. A gravity type of open spillway, having a 30-in. drain and valve in a block of concrete at one end was provided.

When the labor from the various relief agencies became available, the experience had been such that it was felt that a small dam could be designed which would utilize a minimum of concrete, metal pipe and other materials which had to be purchased and a maximum of labor in the placing of earth. Then the standard earth dam for impounding water on waterless properties came into existence. The same earth cross-section was used in these dams as at Lincoln State Park, except that frequently two cut-off trenches were used, one at the downstream limit of the upstream impervious third of the fill and the other located about two-thirds of the distance from this cut-off to the upstream toe of this section.

Present design

In keeping with the theory of an impervious upstream third of earth fill and a slightly pervious downstream two-thirds of earth fill, a tile drainage field is placed at, or below, normal ground level under the downstream half of the dam to take care of percolation and prevent damage from this action.

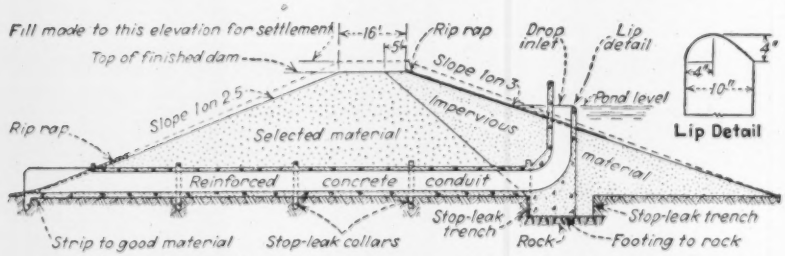


FIG. 2—STANDARD EARTH DAM TYPE adopted by the State Department of Conservation of Indiana for forest and game preserves water storage.

In many dams this was not necessary due to the presence of gravel seams which handle this slight loss in a satisfactory manner.

A drop inlet type of spillway, made of reinforced concrete was evolved for these earlier dams as funds for the purchase of concrete materials, drain pipes, etc., were limited. Using the d furnished from the field, a drop-inl spillway was designed for the indivi characteristics of each dam site. T ing the watershed area furnished, t expected run-off for a 200-year flo was computed. Using this figure an available information concerning drop-inlet spillway characteristics, the spillway was designed. Each was inves gated, both as a weir with a given effective crest (less corners) and as a pi flowing full. In the event one of the methods gave a larger size than th other, this larger size was used. B introducing the slope on the lip, Fig. 2 a theoretical increase in capacity of 0.1 was gained. A minimum size of 5x5 f for the interior dimensions of the bo was adopted to facilitate the constru tion of forms and the placing of ste in the structure. With the type of labo and the limited supervision available a the time, it is felt that much was gaine by this detail. It is the belief that a hydraulic jump is created at the bott of the drop-inlet where the direction an velocity of the water changes from a vertical drop to a horizontal flow. This loss is probably compensated, at leas partly, by the increase in capacity gained by the modified lip construction. The data collected by L. H. Kessler and published in "Erosion Control Structures, Drop Inlets and Spillways," Research Bulletin No. 122, University of Wisconsin, was used as a basis for the theory underlying the drop inlet design.

Later, the forest service of the U. S. Department of Ariculture, under whose supervision the ECW camps in state forests are working, issued a handbook entitled "Design and Construction of Forest Service Dams" in 1935. Dams built on the forest properties complied with the precepts of this book; the changes from former design were negligible. The pamphlet entitled "Brief Instructions on Methods of Gulley Control," by C. E. Ramser, Senior Drainage Engineer, U. S. Bureau of Agricultural Engineering, was used in evaluating run-off data in the light of

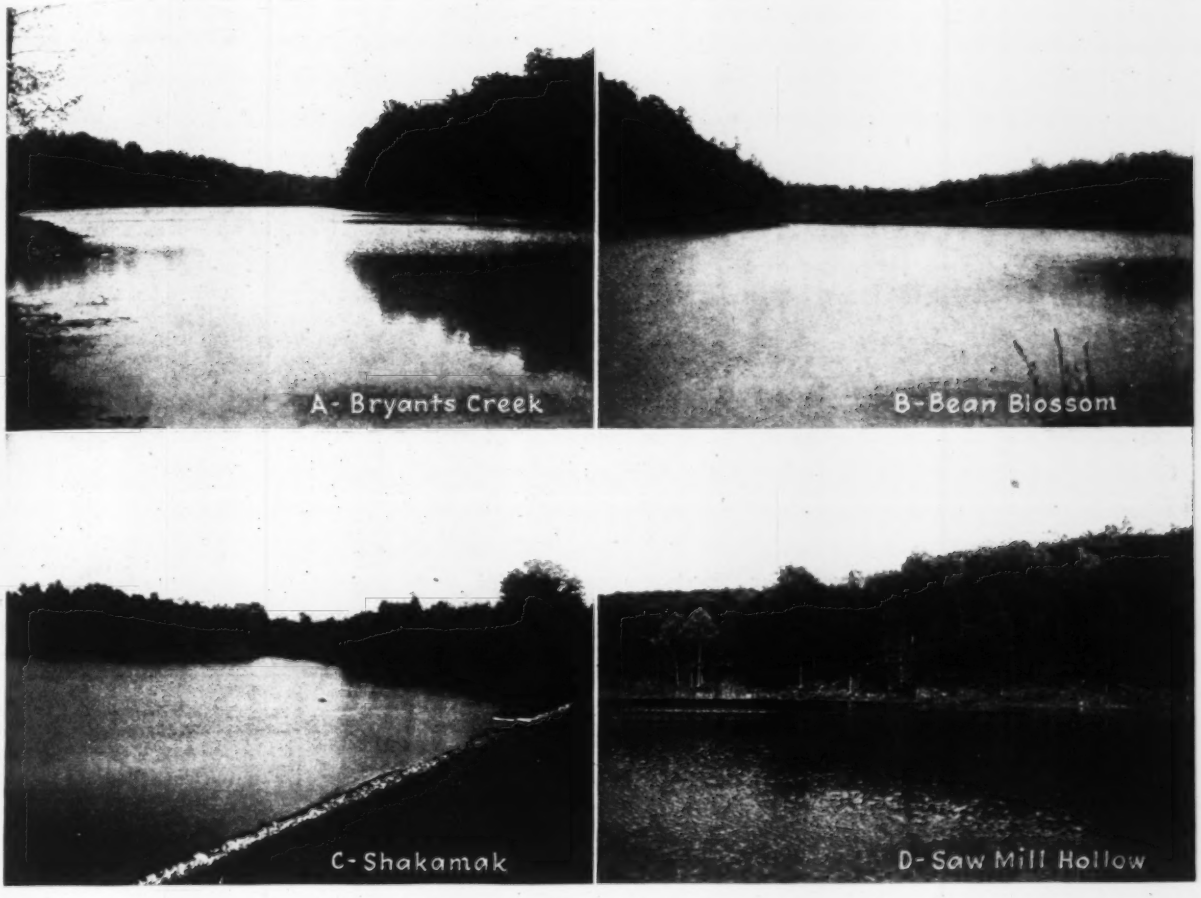


FIG. 3—A GROUP OF SMALL LAKES some thirty of which are being created by small earth dams on intermittent streams in otherwise waterless areas in Indiana. Beginning at the upper left they are: Bryant's Creek, Bean Blossom, Shakamak and Saw Mill Hollow.

soil cover and topographical conditions.

Early in the dam-construction program, a typewritten "Instruction Sheet" was prepared. These instructions were carefully followed, except in one or two instances; this resulted in a couple of minor failures. The example of these part failures, citing the reasons underlying them, had a salutory effect on all other like operations, in that instructions were carefully followed and good results obtained. Minor leaks in the two dams were easily corrected by the use of highway mud-jacks, for placing cement-clay grout in the seepage planes.

Early in the dam construction program, the selected, impervious materials for the upstream third of the dam were picked from the nearest practicable borrow pit, particular attention being paid to sand content and cohesive powers of the clayey material. This selection was made by the engineer and the geologist representing these two divisions of the conservation department. This procedure has gradually evolved into a more scientific method of selection. Samples of the material proposed for use are submitted to the testing department of the State Highway Commission of Indiana for a sieve analysis. Any material not passing this test in accordance with the standards prescribed, is not used in the fill. The same materials used in the upstream third of the dam are used in the cut-off or stop-leak trench which lies under the downstream portion of this upstream third. Materials on the border line or slightly substandard are used in the downstream two-thirds or pervious section of the dam in accordance with the theory of design which allows a slight amount of seepage through this portion.

After materials have been approved for the cut-off, or stop-leak trench backfill, for the upstream third or impervious section and for the downstream two-thirds or impervious section, the construction of the earth fill is started. The stop-leak trench is excavated to an impervious layer of stone or shale. A small cut-off trench is cut into this material to care for any small seams or cracks and any loose material that might lie on top of the impervious layer. The trench is then back-filled with the impervious fill material in 6 to 8 in. layers and compacted with a tractor-drawn sheepsfoot roller. Care is taken that no materials caving from the sides of the trench will be incorporated in this fill.

After this trench is backfilled to about normal ground surface, the top layer of earth covering the original ground surface is removed over the entire surface to be covered by the dam, to a point well below the root zone of the vegetation which existed on the dam site. In some cases, this excavation is made at the same time that the excavation is being made for the cut-off trench. When a satisfactory level is reached, that is, one free from roots and other vegetable matter, the fill for the dam is started. This fill is carried up in 6- to 8-in. layers, is made of the materials approved for the two portions and is compacted by the use of sheepsfoot rollers. The moisture content and the amount of compaction were formerly measured by the judgment of the engineer and by simple non-standard penetration tests. Now the standard methods evolved by R. R. Proctor, field engineer, Bureau of Waterworks and Supply, Los Angeles, Calif., covering both these points, have been adopted as regular practice.

It is felt that the latter method of compaction is the best obtainable for the conditions and materials. A recent test, both by use of the penetration needle and by standard field and laboratory tests in accordance with the method

evolved by Mr. Proctor, shows almost perfect compaction, that is to say, the compaction of the material in the earth fill, as tested in the field, very closely equals the compaction of the same material when tested by laboratory methods. This indicates that the selection of the material, its placing and compaction is being handled properly in the field.

Virgil M. Simmons is the commissioner of the Indiana Department of Conservation, W. K. Hatt, School of Civil Engineering, Purdue University, is state engineer, Ralph Esarey is Director of the Division of Geology, and the writer is assistant state engineer in active charge of the division of engineering.

Large Dredging Fleet Assembled For Filling Golden Gate Fair Site

Eleven suction and hopper dredges used—Island grows at rate of 3,500,000 cu.yd. per month—Total of 25,000,000 cu.yd. to be placed on shoal area in San Francisco Bay—Costs and rates of progress

THE SITE for the Golden Gate International Exposition to be held in 1939 is an island now being built up in San Francisco Bay on a shoal area just north of Yerba Buena Island, the midpoint on the new San Francisco-Oakland Bay Bridge. The land thus made with material dredged from the bay bottom is to be used for a municipal airport after the exposition closes. One of the large buildings (already under construction) is a permanent steel structure designed for ultimate service as a hangar and will be refitted as such when the exposition is over and other buildings are removed.

The exposition is scheduled for the period from February to December, 1939. Before the date of opening plans call for the expenditure of $5,000,000 in an area 3,000 ft. wide by 5,000 ft. long, entirely on fill placed by dredging. Four-fifths of the total cost was secured in a WPA grant and one-fifth is being provided by individual sponsors guaranteed by the exposition organization. The WPA grant totals $3,876,000, for which final papers were signed in December, 1935. Funds began to be available in February, 1936, and actual construction operations began at that time. By the first of this year the filling project was approximately 70 per cent completed under the direction of the U.S. Engineer Department. The total cost of the work to be done under Army engineer direction was estimated at $3,803,000; this part of the work is to be completed by August, 1937.

General construction program

The original plan was to use government equipment to get the work started quickly and to continue it only until the general construction program could be outlined and contracts awarded. Thus when the first funds were available seagoing hopper dredges of the U.S. Engineer Department went to work immediately filling in the deeper portion of the shoal area. Early in February, 1936, the government pipe line dredge Sacramento started pumping. Bids for the fill were called for early March, 1936. When no bids were received it was decided to bring in more government plant, rent whatever additional equipment was needed and carry on the filling to completion under direction of Army engineers.

That portion of the job involving placing a rockfill around the perimeter of the site was readvertised and three bids were received. Unit prices and quantities in this work are given in Table II.

The general construction plan was to throw a horseshoe-shaped fill around the outer edges of the site first and then to raise the fill by successive operations from the inner or southern end of the partly enclosed area, working toward the open end. By this plan the fill will be made of the heavier dredged material without trapping the fines which it was desirable to force ahead of the more stable material. As was planned, the fines have moved on out through the opening in the surrounding embankment and this escape accounted for much of the difference between the total of 25,000,000 cu.yd. handled by dredges and the 20,000,000 cu.yd. which is the net volume of the theoretical prism of the fill up to El. +13.5. The pay limit on the dredged fill is a slope of 1:6 although as steep as 1:4 is permitted. The actual slope has been found to be between 1:5 and 1:6.

Soil surveys were considered at the outset but actually were not undertaken until a heavy settlement occurred after a considerable deposit of dredged fill in the northeast portion of the area. With the importance of a material study thus emphasized, a survey was made. This resulted in the decision to flatten the side slopes where conditions were bad and to place a mattress beyond the toe of such slopes to prevent slipping and heaving. Further, in the location where borings yielding undisturbed samples showed conditions far worse than the preliminary borings indicated, a trench 300 ft. wide was excavated to a depth of —45 along the toe of the proposed fill. The soft mud so stripped off was replaced immediately with a heavy grade of dredged material.

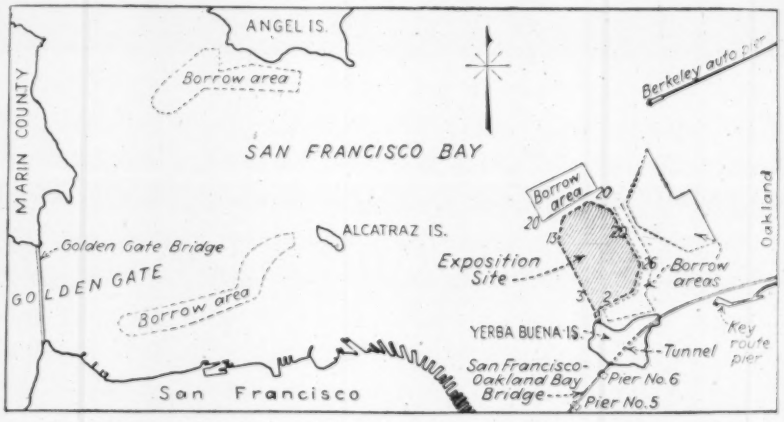


FIG. 2—PLAN OF EXPOSITION SITE showing its relation to the Bay Bridge and fill material sources. Figures in exposition area indicate depth in feet before filling began.

When the work was begun the depth of water over the site varied from 2 to 26 ft. with the deeper portions and the softer bottom in the easterly portion. The rockfill on the perimeter was not started until a foundation for the rock was brought up to El. —6.

The outer slope of the rockfill is specified as 1:1½; the inside slope is allowed to remain at the natural angle except that this may not be steeper than 1:1. As the more severe wave action is expected on the west and the north sides of the fill, class *A* rock is used there—and there only. Class *B* rock is considered sufficient on the east and south sides; these sides do not face along

FIG. 1—EXPOSITION SITE as it appeared on January 19, 1937. Yerba Buena Island and Bay Bridge in background. Filling progressed toward open end, allowing fines to escape. Ferry slips under construction on San Francisco side.

stretches of water in which waves could be built up by the wind.

The firm to which the rock contract was awarded was formed expressly for this bid by four contracting companies. As each of these planned to, and did, use its own equipment on the job, various methods of rock placement were employed. Some rock was put in with clamshell derrick barges and some was dumped directly into place without rehandling from hopper-bottom barges.

Dredging operations for the fill behind the rock wall were coordinated so that as nearly as possible the earthfill closely followed placement of the rock. Successive layers of rock are carried up to a finished top level of El. +14. The specified level for finishing the earthfill over the entire area is +13. No credit is taken for material above this level and anything over El. 14.5 must be leveled off.

The first equipment on the job were the sea-going hopper dredges, MacKenzie and Culebra. In early February,

TABLE II — ROCK CLASSIFICATION FOR WALL AROUND FILL

Rock Classification	Quantity* (tons)	Bid Price (dollars per ton)	Max. Size	Min. Size	Percentage Limitations
A	61,000	1.75	3 tons	500 lb.	50% must weigh 1 ton or more
B (quarry run)	58,000	1.25	1000 lb.	fines	50% must weigh 200 lb. or more; not more than 20% may be 3 lb. or less
C (quarry run)	90,000	1.10	400 lb.	fines	50% must weigh 150 lb. or more; not more than 25% may be 3 lb. or less

* Later revisions brought rock quantities up to a total of 287,000 tons.

TABLE I — DREDGING EQUIPMENT AND PERFORMANCE ON GOLDEN GATE EXPOSITION FILL

Dredge	Owned by	Type	Size	Dredging pumps (h.p.)	Months employed (in 1936)	Yardage Per mo. (cu. yd.)
CULEBRA	U. S. Engineer Dept.	Hopper	2258 cu. yd. hoppers	700	6½	475,000
MACKENZIE	" " "	"	1450 " " "	800	3	400,000
SAN PABLO	" " "	"	525 " " "	400	3	125,000
KINGMAN	" " "	"	1437 " " "	800	2½	375,000
CLATSOP	" " "	"	1050 " " "	500	3½	225,000
SAN JOAQUIN	" " "	Pipe line	20-in. disch.	750	9½	275,000* to
SACRAMENTO	" " "	" "	2 " "	750	9½	400,000 each
MULTNOMOH	" " "	" "	24 " "	900	8	400,000
MARSHALL HARRIS	American Dredging Co.	" "	27 " "	2,500	5½	650,000
S. G. HINDES	San Francisco Bridge Co.	" "	21 " "	2,000	4	550,000
TUALATIN	Hydraulic Dredging Co.	" "	30 " "	2,000	2¼	1,250,000†
MONARCH	Olympian Dredging Co.	Clamshell	5-cu. yd. bucket, 225 ft. boom	.....	5½	60,000
AJAX	Pacific Bridge Co.	Derrick Barge	3-cu. yd. bucket, 125 ft. boom	.....	.....	.....

* Varied with material and length of discharge line.
† A maximum figure. Under less favorable conditions only a fraction of this total.

1936, they began to dredge material from shoal areas of the bay and dump it on the exposition site where the water depth was 25 ft. The San Pablo also was put to work and soon afterward the Sacramento started pumping material into the southwest corner. About the first of April the San Joaquin, after being refitted in the Navy Yard, was put in service. The Multnomah was towed down from the Columbia River to go to work about mid-April.

By mid-May the government was advertising for additional dredging equipment available for rent. As a result of this the Marshall Harris went to work July 15 on a monthly rental basis. The terms were that the government would supply power and the dredge was to guarantee a minimum yardage delivery; there also was a bonus and penalty clause. Operation during 1936 always was such that a bonus was earned. In August two more dredges were rented, the Stetson G. Hindes of San Francisco and the Tualatin which had to be towed up the coast from San Diego. Early in September the Clatsop, a hopper dredge from Portland, joined the fleet. The Culebra, needed on the Atlantic coast, left the exposition work permanently in October; later the Kingman and the MacKenzie were brought back to the job when winter storms made it impractical to work longer in more exposed locations on the north Pacific Coast. In addition to the hopper and suction dredges some of the clamshell type have been used for dressing side slopes preparatory to placing rock.

Performance records

Because the shoal point of the entire area to be filled was at the southwest corner, this was the logical place to begin the fill placed by the suction dredges. The deepest water in the easterly portion of the fill was the logical place for the hopper dredges to start work. Accordingly, the south line was built up by pumping and the east line, to the limits of flotation, by the hopper dredges. A considerable amount of material is being brought in by the hopper dredges and dumped as stockpiles to the east and north of the fair site whence it can be rehandled by suction dredges as the fill progresses.

The dredged material varied greatly in density and weight so performance records of the dredges were affected accordingly. The heaviest material used was the sand brought in by the hopper dredges, which weighed as much as 138 lb. per cu.ft. Average dredge performances as recorded in Table I are for a 24-hour day for 6 days each week in the case of rented plant and 5¼ to 5½ days per week on government plant. Yardages delivered by the suction dredges naturally varied with the length of the pipe lines as well as with the density and percentage of the material pumped. The percentage of solids handled by the suction dredges averaged about 14 per cent. Average performance of the six pipe line dredges in the last three months of 1936 totaled 3,500,000 cu.yd. per mo. (measured in borrow pits).

A causeway 900 ft. long is being built to provide a highway connection from the exposition grounds to Yerba Buena Island. This is a fill with a top width of 100 ft. and side slopes of 1:2. Beginning at the +13 level of the airport the causeway rises to El. 52 where it joins the road system built on the island. For the higher parts of the causeway the fill will be made with excess material excavated in making the road [illegible] from the causeway along the [illegible] Yerba Buena Island to the San Francisco-Oakland Bay Bridge.

In charge of the work for the U.S. Engineer Department are Lt.-Col. [illegible] Dorst, district engineer; Capt. [illegible] Butler, chief of operations on this project and Frank E. Frey, resident engineer. The contractor for the [illegible] is the Marinap Corp. formed for the purpose of carrying on this work by four firms, namely, the Basalt Rock Co., Blake Bros. Co., Daniel Contracting Co. and Hutchinson Co.

Hot Weather Concreting

IN CONTRAST to widely studied methods of safe placement of concrete in cold weather, the work now under way at Imperial Dam on the Colorado River faces the opposite extreme of finding means of placing concrete in temperatures so hot that normal operation may not be possible. Because of the heat concrete ordinarily is not placed on this job between June 1 and Oct. 1 in those parts of the structure at a level above El. 160, which is ordinarily water level at low flow. However, by the use of certain simple expedients concreting has been carried on safely under temperatures which would have made placement impracticable if precautions were not taken. These precautions begin with control of the temperature of the water, include treatment of the aggregate and precooling of the mixer, delivery pipe and reinforcing in the forms.

During the summer months temperatures on this job occasionally reach 118 deg. F. in the shade. The mean for the summer months is in excess of 100 deg., temperatures of 106 or 107 are usual and many summer days range from 110 to 114, and the humidity is very low. Under these conditions the several tons of metal in a concrete mixer comes up to air temperature and it becomes necessary to run cool water through it for 10 or 15 min. before the first batch is put in.

On this job a deep well is available which supplies water at 70 deg. F. This water is used for mixing during the hot weather period and also is more effective than warmer water would be for the various cooling operations used to aid hot weather placement.

Ordinarily the aggregate is hauled direct from the screening plant to the mixer storage bin and thus advantage is taken of the cooling effect of recent washing. When material has to be taken from the aggregate bin it has been found advantageous to surround the bin with a burlap covering on which water sprinkles continually. Just before pouring concrete the forms are given a final sprinkling and particular attention is given to cooling the reinforcing steel in this way.

The maximum permissible temperature in concrete at the point of placement has been set at 85 deg. F. It is doubtful whether this requirement could be met in hot weather without special precautions in the delivery pipe line, 8 in. in diameter, which is used for pumping concrete to some parts of the work. In addition to the precautions already mentioned, methods are used which, instead of allowing the concrete temperature to increase in transit through the exposed iron pipe line, actually reduce the temperature 1 to 3 deg. during the period of its transit through the 300-ft. delivery pipe. This is accomplished by covering the pipe with burlap on top of which a small water pipe is laid for the full length of the line. Closely spaced perforations in the small pipe allow 70-deg. well water to trickle continually onto the burlap. The rapid evaporation under the sun's rays and in the dry desert air accomplishes a greater amount of cooling in the line than would be obtained under ordinary climatic conditions. The custom is to cool the line for an hour or two in this way before starting to pour concrete.

An illustration of the cooling effect possible with the rapid evaporation that attends low humidity appears in cold-weather experience at Imperial Dam. Since the start of the work ice has formed several times in some of the water supply lines on the job at a time when air temperatures were known to be several degrees above freezing. Because of this apparent contradiction of thermometer readings attention was drawn to the conditions where the ice occurred, and it was discovered that in every case there was a small leak. The leak, by wetting a metal surface, resulted in evaporation so rapid in the very dry air that adjoining metal was cooled to a temperature below freezing and actually caused ice formation.

Earthquake-Resistant Design For New School Buildings

Experience in applying California's structural law of 1933, the "Safety of School Houses Act"—Methods and details used in buildings of wood, steel, concrete and brick

By Harry W. Bolin
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IN THE THREE YEARS that have elapsed since the "Safety of Construction of Public School Buildings Act", popularly known as the "Field Act", has been effective in California, new school buildings costing more than $20,000,000 have been built with earthquake-resistant features in Southern California. This is in addition to the cost of reconstruction of existing school buildings found to be structurally defective. Although a large amount of rehabilitation work has been done on schools in all parts of the state, the greater amount of new school construction has been in Southern California. This, in part, is because the destructive effect of the 1933 Long Beach earthquake made it necessary to erect a number of new school buildings in the area affected. Responsibility for checking plans of these new buildings and seeing that requirements of the new law were met has rested upon the division of architecture. With the experience in this work as a background, endeavor is made to set down in the following, facts and conclusions about seismic-resistant design which may be useful to structural engineers in working with similar problems elsewhere.

In general, the design provisions which are used to make buildings more earthquake resistant, simply give the structures greater rigidity with which to withstand horizontal forces. The method of accomplishing this is to apply certain coefficients (seismic factors) which have been selected as satisfactory for giving resistance to seismic forces of certain assumed acceleration values. The assumption is made that static design forces proportional to the inertia of a building are equivalent, in effect, to the complicated dynamic forces known to occur during earthquakes. It is important to keep in mind that although the objective is to provide resistance to forces acting *horizontally*, the seismic factors are applied to *vertical* (gravity) loads, i.e., the horizontal forces taken into account when seismic factors are applied, are percentages of vertical loads. However, the effects of vertical accelerations are not neglected.

The seismic factors vary in amount and depend on the nature of the framing or articulation of the building and the nature of the soil or foundation material upon which the building rests. The minimum factor is two per cent (0.02 g.) and the maximum is ten per cent (0.1 g.). Special provisions are made for buildings supported on piles or caissons. When seismic factors are being applied it is permissible to use working stresses one-third higher than those employed when figuring dead and live loads only.

Some cities have building codes with stress limitations more stringent than those imposed by the Act. For example, in Los Angeles the building code requires all new school buildings, regardless of type of construction, to be designed with a seismic factor of ten per cent (0.1 g.) as compared to less exacting requirements stipulated in the Field Act.

Although school buildings vary (1) in size, (2) in function and (3) in materials used in their construction, the basic design of rigid earthquake resistant structures is generally applicable because they rarely exceed two stories in height and have plan dimensions large in comparison to height. In the rigid type of construction, the forces produce principally shear deformations rather than deflections of flexible members. A rigid structure should be so proportioned and interconnected that the entire building acts as a unit when shaken by ground movements. In addition, the structure should have incorporated in it a framing system which will deliver the forces caused by vibration of the ground back into the foundation as directly and as quickly as possible.

The simplest type of structure to satisfy conditions of rigidity is a building of rectangular plan and uniform

FIG. 1—WELL-DESIGNED wood frame building of Roosevelt elementary school, with exterior stucco on diagonal sheathing.

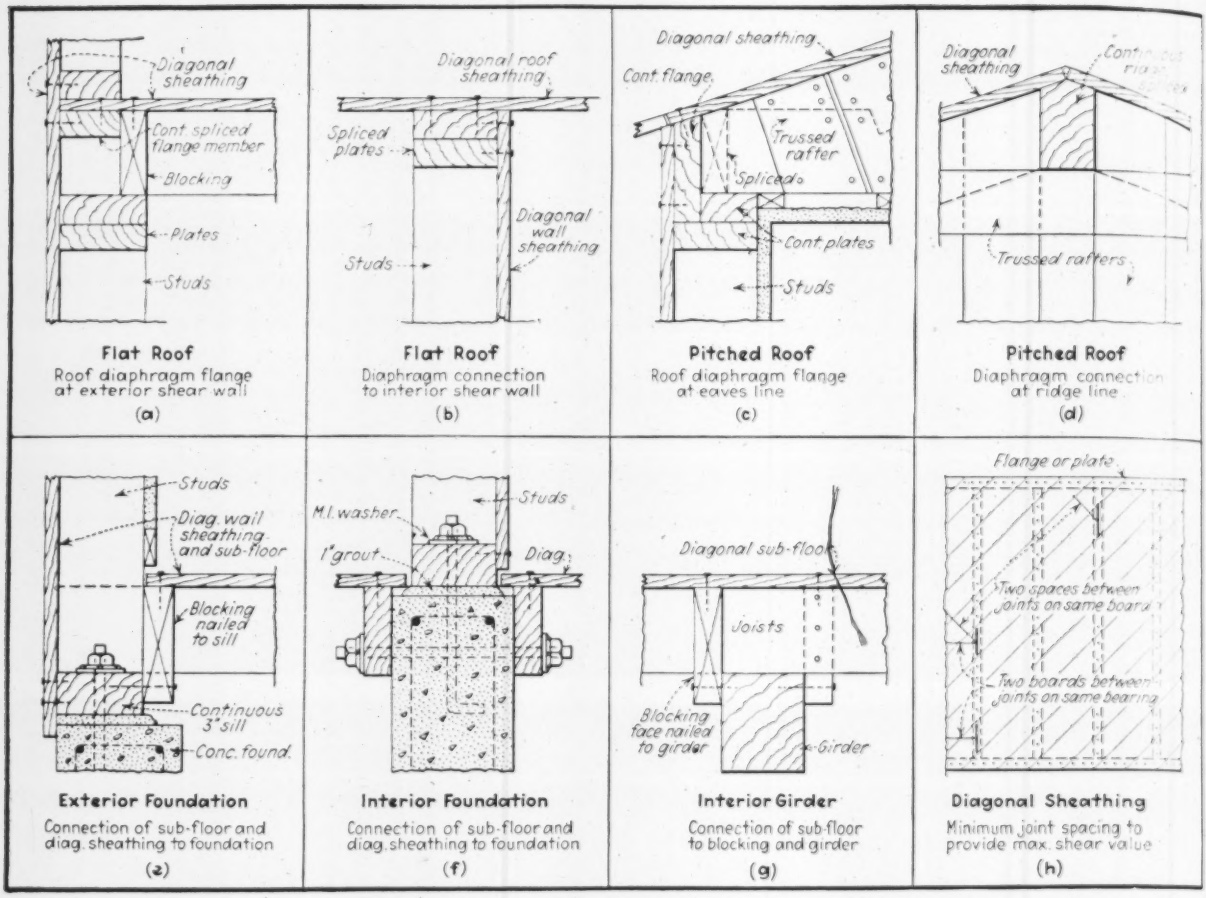


FIG. 2—WOOD FRAMING DETAILS USEFUL IN DESIGNING FOR LATERAL FORCES.

height. It is good practice to avoid torsion or eccentricity by separating parts of buildings which have a complex plan, that is, which have shapes resembling the letters *L*, *E*, *U*, and *H*, or which have distinctly different heights in different parts of the building. In some cases, however, the critical sections or structural members common to dissimilar parts of irregular buildings are provided for without separation, but the design must take into consideration the moments and shears due to the eccentricity of the applied forces with reference to the center of resistance.

Two fundamental considerations are essential to any system intended to resist horizontal forces and give rigidity to a structure; these are (1) horizontal elements and (2) vertical elements. The horizontal elements must act as beams, girders or trusses with the primary purpose of delivering horizontal forces to reaction elements. The horizontal elements also are used to supply lateral supports, stays or ties for the vertical elements. The vertical elements, usually vertical cantilevers or braced frames, which are the reaction members for the distributing elements, fulfill the function of delivering the horizontal forces to the footings and thus to the underlying foundation. In a system of this sort it will be seen that limiting the deflection or distortion of structural members is highly important and that it is just as necessary to consider deflection as it is to consider strength, particularly where plaster, masonry or other fragile, brittle and rigid materials are involved.

Legal requirements

The Field Act provides that school buildings shall conform, in design and construction, to rules and regulations formulated by the division of architecture. Appendix *A* of these rules and regulations sets forth in detail the requirements as to loads, horizontal forces, quality of materials, stress limitations and construction procedure. This appendix in many respects is similar to city building codes, but it includes provisions considered necessary for carrying horizontal forces which are based on analytical rather than "rule of thumb" methods. The practical results of applying provisions of the Act are as follows:

Alterations, reconstruction or additions to existing school buildings do not come under the provisions of the Act when costs are less than $4,000, but all new buildings, regardless of cost, which are to be used for public school purposes must comply with the law. Plans and specifications must be prepared by a licensed architect or a registered structural engineer, must be approved by the division of architecture, and construction must be carried out under the continuous inspection of a representative of the architect or structural engineer, and under such general supervision as the division of architecture deems necessary.

Wood frame buildings

Timber construction is used extensively in California for classroom buildings one story high, particularly in rural districts. The structural elements ordinarily used in such buildings may be effectively arranged for distributing and resisting horizontal forces. The roof sheathing can be used to transfer forces to walls or vertical frames by designing the roof planes as thin plate girders in which the sheathing is the web and the rafters are stiffeners. In such design it is necessary to have members comparable to flanges (often referred to as "moment strips") so for this purpose use is made of parts of the structure designed primarily for carrying vertical loads, for example, the ridge pieces of gable-type roof and plates at exterior walls and partitions

Sheathing laid diagonally has been found most effective because forces then follow the lines of the sheathing boards. When sheathing is placed normal to the rafters resistance to beam action must depend upon couples formed by the nailing of sheathing boards to rafters—a less rigid and less dependable design. When elements of a building are combined as suggested in the foregoing, into relatively large planes or panels of solid sheathing, whether for the purpose of distributing forces or resistance to shock, they frequently are called "diaphragms."

If the desired rigidity and resistance to horizontal forces is to be obtained through the use of sheathed diaphragms it is important that particular attention be given to the design of certain details. Some of these are (1) flange splices which must function effectively either in tension or in compression; (2) direct and adequate connections of frame members to end walls or to walls parallel to the direction of forces; (3) rigid connection between the horizontal diaphragm and side walls so that forces originating in the side walls may be transmitted to the end walls or resisting elements; (4) proper spacing of rafters, or joists, to keep the L/b relation of the sheathing boards within permissible limits which are imposed because the boards at times become compression members; (5) adequate nailing of sheathing boards to "moment strips" and to rafters and (6) separation or staggering of adjacent board joints in the sheathing. Typical details are shown in Fig. 2.

In the analyses of framing members forces must be considered as acting in two directions, that is, longitudinally and transversely. When the forces are normal to the rafters, the rafters actually are not stiffeners in the sense of plate girder stiffeners, but are very likely to undergo beam bending action in a sidewise direction. In this case the side walls and corridor partitions become the reaction elements.

Other methods of securing distributing elements are to use beams or trusses near the plane of the ceiling. Here the same attention to details is necessary as in the design of diaphragms. In buildings with ceiling and roof planes and having the horizontal framing placed in one or the other, vertical framing or sway bracing must be provided to insure delivery of the forces from the unbraced plane to the horizontally framed plane. In all of this work members must be so disposed that shrinkage of the wood will not affect the strength or rigidity of individual joints or of assembled panel units.

Floors and foundations

Wood floors of present day construction are excellent diaphragms (provided, of course, that attention is given to periphery details) because the subfloor sheathing usually is laid diagonally and has but few openings. Joists are bridged between supports and are solidly blocked at the supports. Foundation walls generally extend at least to the soffits of the joists so details of connecting floor diaphragms at their edges and sides differ from those used for roof or ceiling diaphragms. Where joists rest on sills or ledgers bolted to the foundation walls it is usual to provide solid blocking of depths greater than the joists, thus affording direct face nailing to the sill (Fig. 2-e). Since the sheathing is nailed to the blocking, in effect, the walls become flanges or "moment strips" for the floor diaphragm. Floors usually have relatively less work to do in transmitting forces to walls because the walls themselves, at least to some degree, are designed to provide for their own induced forces.

Vertical resisting elements consist of solid diagonally sheathed walls often called "shear walls" or "shock walls," or braced frames of some type. Sheathed walls are considered to act as cantilevers and hence must be firmly connected to the foundation walls. Where walls or partitions which constitute resisting elements are pierced with openings it is necessary to investigate the piers or wall sections between openings as to anchorage and strength of the studs adjacent to the openings.

Forces are proportioned to piers in accordance with the respective pier rigidities. When braced frames are placed in walls the sloping or diagonal members are considered as either compression or tension members, depending upon their arrangement. In either case the end connections are specially important and warrant detailing so that provision will be made for both vertical and horizontal force components. Braces consisting of metal rods anchored into the foundation wall often are used; it is customary to provide these with accessible turnbuckles so slack can be taken up. Plaster or stucco on walls, particularly where metal lath is used, undoubtedly adds much to wall stiffness. However, it is necessary that this resistance furnished by plaster covering be transmitted to studs and to foundation walls; sheathing and bolted sills are necessary for this purpose.

Wood buildings other than classrooms, such as shops and small assembly halls call for somewhat different treatment. To obtain the best seismic resistance where walls and interior partitions are more widely dispersed, the design must take into account these longer spans and provide devices for distributing forces into the taller resisting elements. In buildings that have roofs supported on wood trusses the simplest method usually is to provide complete horizontal trusses in the direction of longitudinal and transverse axes. In such trusses good practice suggests the use of diagonals consisting of adjustable metal rods. In this type of horizontal framing, prevention of the loosening effect which results from shrinkage is particularly important.

Reinforced concrete

School buildings of all types are constructed of reinforced concrete although roof decks of large area generally are supported by steel trusses. Although concrete construction is heavy and correspondingly large horizontal forces must be provided for, adequate design is not a difficult matter and the resultant structures have the great advantage of rigidity. Concrete is particularly popular for classroom and administrative buildings two stories high. Also it is used extensively for walls of one-story buildings which employ wood construction in floors and roof.

Where concrete floors and roofs are used, whether of (1) thin slabs and ribs, (2) thicker slabs with beams and girders or (3) slabs without beams, the result is to stiffen the building with effective diaphragms. Very often it is possible to have diaphragm floors effective for the full width of the structure which, in the case of a building with a center corridor and flanking classrooms, usually is 60 to 70 ft. (Fig. 3-f). Marginal beams with reinforcing steel to carry tension form the flanges (Fig. 3-e). In buildings of large area the disposition and arrangement of construction joints in floors and roofs together with their design are important because large slabs sometimes are not poured continuously to completion. A common form of jointing is the provision of toothed or keyed joints with steel dowels (Fig. 3-b).

Reinforced concrete walls usually are not less than 8 in. thick and reinforcing is placed in two planes to secure greater effective depth. The reinforcing may be placed vertically and horizontally or diagonally. With the diagonal placement all bars are effective at construction joints; when the arrangement is rectangular only vertical bars act as dowels. It has been found that simplicity of steel placement is desirable to prevent undue congestion of reinforcement. In all cases extra trimmer bars are placed at the edges of wall openings, sometimes diagonally, for the prevention of small corner cracks (Fig. 3-g).

Experience has shown horizontal and vertical construction joints to be planes of weakness when buildings are subjected to earthquake shocks. For this reason special attention is given to the design and location of joints in walls. Horizontal joints usually are provided with toothed or keyed arrangements as well as with dowels. Because of the difficulty in cleaning indented keys placed intermittently, which are notorious debris collectors, such joints are formed by embedding intermittent pre-

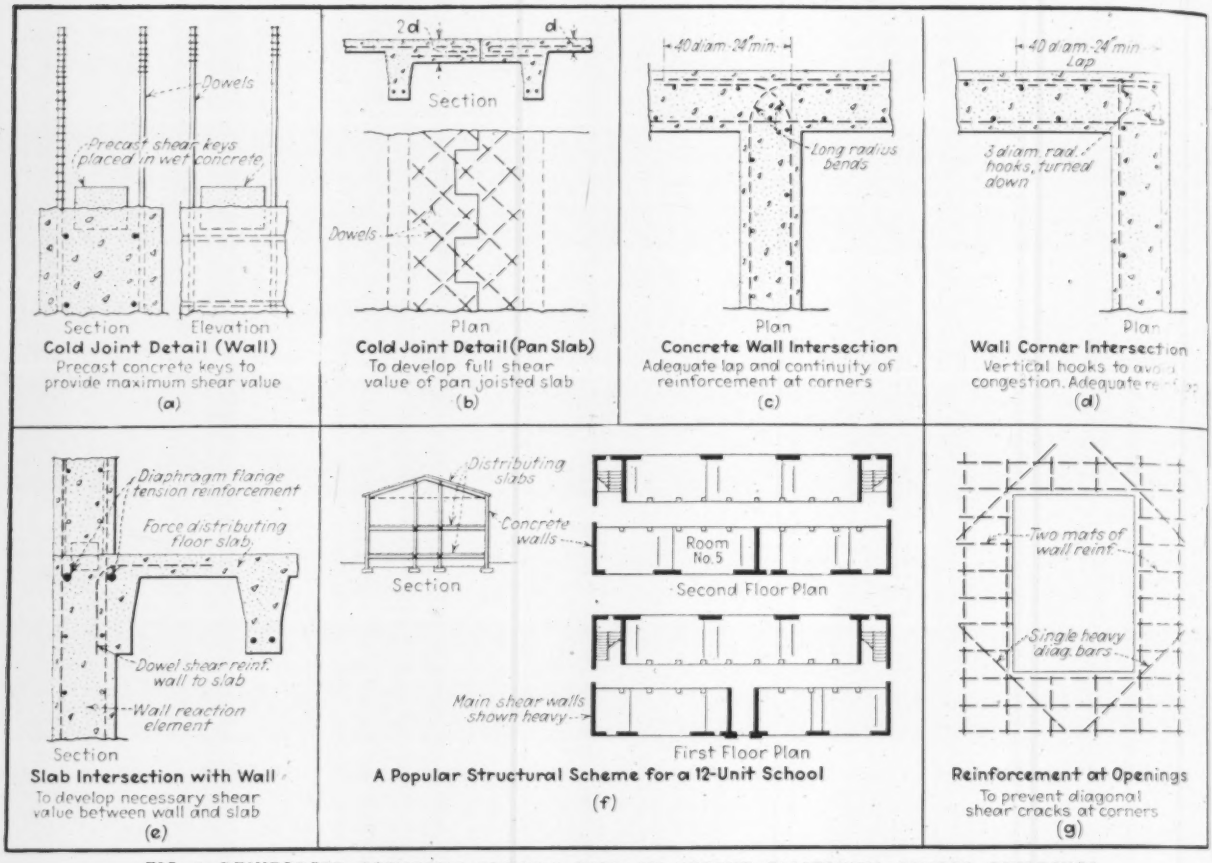


FIG. 3—REINFORCED CONCRETE DETAILS USED IN RECENT CALIFORNIA SCHOOL BUILDINGS.

cast blocks in the fresh concrete in such manner that half of each block projects above the joint plane (Fig. 3-a). The spacing and size of these blocks are determined by the amount of longitudinal shear for which the wall is designed. There is preference for keys, also, at vertical joints, although here depressed types are not objectionable.

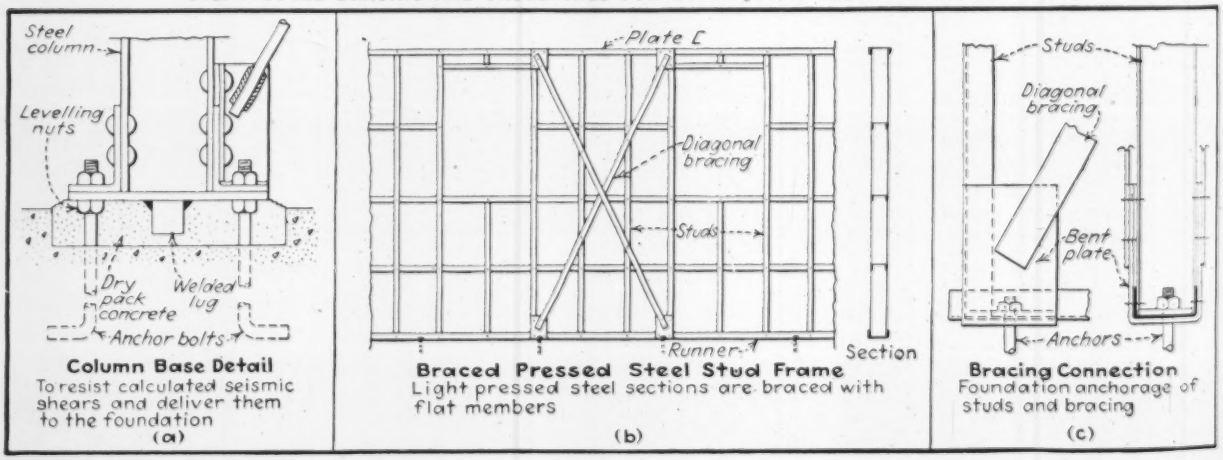
In one-story buildings where wood floors and roofs are used with concrete bearing walls, the horizontal elements consist of truss systems or beams forming *L*-shaped wall tops; such members are known as "wind beams." In buildings of this type, only in special cases and under limited conditions is wood roof construction figured as a diaphragm. However, good practice places importance upon designing all wooden members for minimum deflection.

In reinforced concrete there are some deviations from the almost standard method of providing horizontal distributing members and vertical resisting elements. Some reinforced concrete buildings have been built in which the columns and connecting beams form rigid frames designed to resist transverse horizontal forces. However, even in these cases longitudinal horizontal forces are distributed to the side walls which function as "shear walls."

Structural steel frames

Structural steel frames have been used in various types of school buildings, particularly in two-story class-

FIG. 4—STEEL BRACING AND FASTENINGS FOR EARTHQUAKE PROOF CONSTRUCTION.



room buildings, auditoriums and gymnasiums. Usually they are in combination with wood, reinforced concrete or reinforced brick. Also steel frames have been used to some extent in buildings with floors and roofs made of steel decks.

When steel is used in connection with reinforced concrete floors and roofs, the structural steel frame usually supports the vertical or gravity loads. The reinforced concrete floors and roofs, on the other hand, are designed to distribute the horizontal forces to bearing walls of reinforced concrete which are the resisting elements. In auditoriums and gymnasiums where steel trusses support roof and ceiling, several methods are used for fulfilling the function of horizontal diaphragms. The most common method is to have complete horizontal trusses in two directions, either just above the ceiling or near the roof. Vertical sway bracing also is put in, usually making use of structural steel.

A particular problem is presented when the steel trusses are used to transmit horizontal forces to reinforced concrete walls. In such cases the side walls, that is, walls normal to the direction of the horizontal force, are connected to the trusses and the trusses must be relatively stiff with limited deflections, depending on the rigidity of the connected walls. This same condition holds true when the walls are of reinforced brick.

When steel is used in buildings with stucco walls the resisting elements consist of properly disposed braced frames of structural steel. It has been found that such frames distort somewhat upon the tightening of diagonal members in cases where the vertical members (columns) are attached to footings by anchor bolts in fittings with the usual oversized holes. To overcome this, base plates have been designed to prevent horizontal sliding when frames are made rigid (Fig. 4-a).

In all earthquake-resistant structures connections between horizontal and vertical elements require careful safeguarding against slip or movement. For this reason bolts attached to gussets or other steel fittings are placed in holes with the minimum possible oversize. While connections for vertical loads are riveted or bolted, connections for horizontal forces frequently are welded. However, welding is permitted only by experienced welders who have passed the necessary qualifying tests.

A number of one-story school buildings have been built of a type similar to the ordinary wood frame but with wood studs replaced by metal studs. Walls using metal studs are designed with one or more braced frames within them and the forces are distributed to the frames in proportion to the relative stiffnesses (Fig. 4-b). Particular attention is given to the connection with the foundation walls, and the thin metal sills are reinforced with steel plates where anchor bolts occur (Fig. 4-c). Details are arranged so that all members composing the braced frames are straight and tight.

Reinforced brick

Reinforced brick construction is used principally for walls, and such walls in many respects are similar to reinforced concrete. The reinforcement necessarily must be placed in joints between the withes or in spaces formed by use of specially shaped brick. Generally the effective depths of reinforcement are less than in concrete walls of the same thickness. To insure the effectiveness of brick walls as resisting elements it is necessary to secure full joints both vertically and horizontally, strong mortar, good adhesion between bricks and mortar and good bond between mortar and reinforcing steel.

Vertical steel is stayed by frames or braces to prevent it from vibrating while the surrounding mortar and brick are being placed. Otherwise, the bond between steel and mortar may be broken. Bricks are well wetted before laying to insure good bond and the walls are kept moist for several days while the mortar sets. Special brick construction, in which only the bed and end joints of the outer withes are laid in mortar and interior withes are laid in grout which also embeds the reinforcing, sometimes is substituted for the usual brick and mortar masonry.

Foundations and fastenings

To make sure that an entire building will move as a unit, footings for buildings more than one story high as well as piers, pile groups or caissons are interconnected. The ties or struts which form the connections are designed to carry 10 per cent of the larger load on the two footings connected. When the ground or basement floor is near the tops of footings it can be used as a means of interconnection provided the slab reinforcement is well anchored to the individual footings. Foundation walls should be designed with maximum resistance to overturning or sliding.

Another important feature in connection with foundation design is the investigation of the character of the soil or foundation material. As seismic factors depend on the bearing capacity of the soil it is necessary that the allowable soil pressure intensities be carefully determined. Soil tests frequently are made under conditions considered to be the most adverse which the foundations are likely to meet. Similarly, load tests on piles often are made.

Special features

When considering seismic-resistant factors there are some elements other than the building frame itself which the structural designer should take into account. For example, marble partitions are brittle and fracture easily when vibrated: good design, therefore, suggests that all edges of such partitions be securely fastened and that edges or tops standing free be inserted in metal tubes or sleeves which in turn are secured to the structural elements. Nonbearing partitions should be fastened on all edges and if formed of brittle or easily shattered material should be bonded to reinforced gunite or plaster surfaces. Similar special treatment also should be given to tall partitions formed of metal channel studs with a covering of plaster on metal laths. Care should be taken to anchor all equipment elevated above floors such as water tanks, heaters, etc. Parapet walls should be kept as low as possilde and, considered as cantilevers, should be designed with a seismic factor of 100 per cent (1.0 g.)

Fig. 4-f illustrates a scheme which has been used with numerous variations. The upper slab (shown in the sectional view) is sometimes placed at the ceiling line, using a wood or steel joisted roof. This general scheme provides adequate horizontal distributing slabs at floors and roofs, combined with symmetrically placed resisting walls in transverse and longitudinal directions.

Administration of the Field Act is the duty of the division of architecture, State Department of Public Works. Earl Lee Kelly is state director of public works, George B. McDougall is state architect and chief of the division of architecture, and Clarence H. Kromer is principal structural engineer, division of architecture.

Illinois AAE Assembly Works For Licensing Engineers

Holding that public safety is involved just as much in the work of mechanical, chemical, electrical and mining engineers and in the non-structural phases of civil engineering as in the structural work now licensed, the Illinois State Assembly of the American Association of Engineers has launched a drive for a wider and more effective registration law. The assembly, which was formed last fall in Peoria, has announced in its new publication, *Voice of the Engineer*, two other objectives for the year: publication of a directory of Illinois engineers, and advancement of public recognition of the engineer. This latter problem is being attacked in a novel way in cooperation with the parent association. Members, acting individually, are collecting for analysis all forms of publicity tending to mold society's conception of the profession and its social value. Voters are to be asked to demand engineers on public works boards and commissions, following the precedent established by life insurance companies, and food, drug, and dentrifice companies in their educational propaganda for fuller use of the service of doctors and dentists.

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Right and Duty

DETAILS ASIDE, the recent court decision upholding the New York multiple-dwelling law constitutes a clear-cut recognition of the public right to outlaw bad housing. In other words it says that the mere existence of an unsafe or unsanitary tenement and its toleration in the past does not give the owner a right to keep this tenement in business as long as he pleases. This principle may seem almost self-evident; yet heretofore many slum owners and mortgage-holders believed that they possessed such a right, and that any attempt to enforce minimum standards of health, safety and decency in housing was an attempt to take away their property. Now that the sounder view has been authoritatively affirmed quicker progress in wiping out bad housing is possible, and if such progress is actually realized the erection of proper housing will be sure to follow. Suppression of bad tenements by law is not only a public right but is a public duty. Housing standards will be raised more quickly by such suppression than by setting up competition through public or subsidized housing.

Notable Soil Study

THE INCREASING USE OF RESEARCH as a working tool for road improvement is exemplified in the struggle of Kansas highway engineers with pavement distortion by swelling subgrade soils. The essential facts are told on a preceding page (p. 405). Fundamentally the problem was one of soil mechanics, and ordinarily it would have been considered a matter for laboratory determination alone. In the Kansas studies, however, the laboratory determinations were only a beginning; their results were taken into the field for test under actual working conditions. Further, in order to center the conclusions on soil action, collateral tests were made so that factors not related to soil which might influence pavement distortion could be evaluated and eliminated. The final step was the construction of an experimental road that has few if any equals in equipment for scientific study. Briefly, the soil studies in Kansas combine laboratory determinations with controlled field application and observation—and today this is the greatest need for practical progress in soil mechanics. Command of laboratory tests and mathematical interpretation of results is well enough established to proceed rapidly, provided field observation furnishes the necessary facts. Soil mechanics must get out into the field if its excellent progress in the laboratory is to be a constructive aid in engineering.

Better Small Dams

COMPARABLE TO THE KANSAS WORK on swelling subgrades, advance through utilization of modern soil knowledge was made in a very different field by Indiana engineers, in the work on small earth dams described on p. 409. Refinement of design and construction has not been common in building such structures. While in large earth dams the risk and cost were considered important enough to justify careful differentiation between upstream and downstream fill as well as test control of density and compaction, the small dam was left wholly to rough-and-ready judgment. For this reason the construction of the score of park and game-preserve dams described in this issue, in which the engineers of the Indiana conservation department applied soil mechanics and principles of hydraulic resistance of earth fill, represents real advance. This refinement of design and construction did not call for unusual construction skill, nor for exceptional equipment or greater cost; it needed nothing more than engineering progressiveness. The proved tools of the large dam-builder were taken in hand for application to the small dam and were found serviceable. The result is a definite improvement of structure in one of the most common of engineering works.

Water Supply a Public Function

WATER SUPPLY IS A GOVERNMENTAL FUNCTION, not an incidental business venture, the U. S. Supreme Court has decided in the Brush Income-Tax Case. Reversing a long-asserted view, Justice Sutherland, who wrote the opinion in a 7-to-2 decision, says simply and directly: "The acquisition and distribution of a supply of water for the needs of a modern city involve the exercise of essential governmental functions,"—even though private persons might be willing to undertake the same service. The decision recognizes that government today consists of more than passing laws, employing policemen and collecting taxes—that it includes many necessary services, from clearing streets to distributing water—perhaps also of operating a rapid-transit system. No doubt public officials and employees ought to pay taxes on the same basis as everyone else, but that was not the question at issue in this suit, nor was the plaintiff motivated by a desire to evade just taxation. William W. Brush has done a service to citizens as well as to water engineers in fighting his protest up to the highest court in order to establish a principle of broad importance.

Saving Lives

IN A GENERAL WAY everyone knows that the consistent effort to make water supplies pure has saved many lives. But the latest figures on disease mortality gathered by the Public Health Service are nevertheless impressive, as renewed testimony to the magnitude of the public service rendered by water-supply engineers. Steady cutting of the tragic typhoid mortality figure has brought us to the lowest record in history, an achievement that is wholly the result of steady progress in water treatment and service. The excellent typhoid performance coincides with a new low figure in the death rate from all diseases, but with a difference in cause, for typhoid is independent of the factors that contribute to susceptibility to ordinary disease. Whatever cause may be credited for the low general death rate during the depression years of '31–35, it is certain that domestic water use was not affected by the economic conditions of the period, and that the typhoid reduction is solely the result of technical progress. It is worth remembering that the change in the typhoid death rate by as little as one point per hundred thousand means more than a thousand lives saved per year, and the importance of water improvement should be

measured in these terms. Even the typhoid figures tell only part of the story, however, for polluted water is the source of many other derangements, which, though less fatal, probably entail costs comparable with the loss chargeable to typhoid itself. We have reason for being gratified with past progress. At the same time it is well to keep in mind that there is room for further improvement. The justification for continuing advance of water science and art is that no single element of municipal investment pays higher dividends.

Flood Protection and the Mississippi

WITHIN LESS THAN 24 MONTHS events have occurred that give cause to think deeply on flood hazards and protection. The unprecedented height and violence of the floods of 1935, '36 and '37 has brought us face to face with a problem of national scope. Flood hazards are countrywide, and what happened along the Connecticut, the Conemaugh and the Ohio will happen in other river valleys sooner or later, perhaps tomorrow. In fact even worse is ahead, for there will be even greater and more calamitous floods.

In thinking of this great national problem it should be realized at the outset that we are not going to end floods in a day—nor in a year or even a generation. Nor will the dirt fly tomorrow, despite demands from stricken communities for instant action. If there is one outstanding lesson in the thoughtful discussion of flood-control procedure by Arthur E. Morgan, past master of the art, that appears on p. 461 of this issue, it is that no flood-control undertaking can be planned well without exhaustive study of every possible method before deciding on what is to be done.

Unfortunately, exhaustive exploration of flood problems has not been common, and this is true especially of the Mississippi, our first and largest national flood-control undertaking. After the 1927 flood a hurried survey was made to outline a protection project, with estimates of cost ranging up toward a billion dollars; but presidential fiat prescribed that only three hundred millions should be spent, regardless of what the problem might require. This decision set the stage for makeshift procedure, for revision, unsettlement and threat of disaster, culminating in the War Department's panicky announcement six weeks ago of a plan to evacuate the entire valley for fifty miles from the river—the same War Department that had proposed the flood-control project as a permanent safeguard against floods and had received authority to carry the project into execution.

It is important to keep in mind that most flood hazards are man's own fault. Floods never sweep over the uplands but are confined to their own valleys, and their destructive action strikes only those who occupy the land that was shaped by the river in the past and is periodically reoccupied by it. Under these conditions, to work out the best compromise between man's and nature's demands is bound to be an intricate, patient study.

To complicate the problem further, no one is able to say definitely how great a flood may come to pass. Accumulated experience is sadly incomplete, and while much has been accomplished through skillful concentration of experience we have not yet arrived at a trustworthy figure for the maximum intensity of floods. The best that can be said today is that no river has yet had its greatest flood. Because of this fact no flood-protective works can provide security unless they embody a large margin of safety. Indeed, without such margin, a river wall, a levee, and often also a reservoir, may be the cause of far greater disaster than it was intended to prevent.

The Ohio and the Mississippi are today in the forefront of attention, not only because of the cost and suffering attendant on the recent flood but also because they present the largest and most difficult flood problem we have. Along the Ohio the situation is perhaps not critical; for, though it is fairly certain that even this year's flood did not reach the maximum possible height, yet the topography of the valley lessens the danger. If the lower ground is evacuated, and if the community service centers such as water and power plants are placed where they will be safe in every contingency, the effect of possible increased flood volume will not be disastrous.

The Mississippi, however, is exposed to far greater risks, as those who dwell in its valley know. With levee protection as their main dependence, the lowland dwellers must be protected up to the very top limit of possible flood height, for once the flood goes over the levees widespread destruction is certain. The Jadwin plan of 1927 set a limit to the possible flood volume, but the experience of January and February demonstrated that this limit is too small. The valley that was to be made safe has not been made safe.

Nine years ago we urged that the Mississippi Valley's flood problem be investigated thoroughly, and that no pertinent consideration be neglected. We pointed out that the assumed maximum flood, the "superflood" on which Jadwin and his collaborators based their planning, was open to question. Since then, manful work has been done in revising the project, removing errors, salvaging the good and eliminating the bad. But we still have the old superflood. We still have the menacing "fuseplugs". We still have nothing more than a tremendously costly flood-confining plan without storage or conservation, without consideration of any of the uses and effects of the river other than flood. To review and reorient the entire Mississippi plan is therefore the first step of progress in our flood problem.

When the first days of February saw water pouring into the Mississippi from the Ohio, and when this single tributary sent down a volume virtually equal to the project superflood, earlier doubts concerning the inadequacy of the project works were confirmed. A flood in the Missouri or the upper Mississippi combined with an Ohio River flood of 1937 volume will overtax the Mississippi's works and drown out the valley. This fact in itself justifies searching review of the project. But in addition, since the project was planned for the protection of the main river alone while the tributaries now are believed to require storage to protect their own valleys, the whole aspect of the Mississippi problem has changed.

All the facts of today therefore, demand a fundamental review of the Mississippi project. The uncertainties of the plan, the questions as to calculation and economics, the relation of general and local hazards, should be explored by thoroughgoing investigation. The existing project, based on rejection of conservation and reservoir storage and on inadequate flood prediction, should be restudied to take account of the facts and situation now at hand.

CURRENT NEWS

Tenement Remodeling Upheld by Court

Provision in New York law requiring owners to make sanitary and fire safety changes upheld by highest state court

By unanimous vote, on March 9, the New York Court of Appeals upheld the provisions of the multiple dwelling law which require that changes shall be made in all tenement houses erected prior to 1901 in New York City to bring them up to minimum standards as regards sanitary facilities and fire safety. The case decided was that of the appeal of John B. Adamec, owner of a tenement house in the Bronx, against Langdon W. Post, Tenement House Commissioner of New York City. The plaintiff was directed to make changes in his property to comply with the multiple-dwelling law.

Judge Irving Lehman said in the opinion: "At the point where economic self-interest ceases to be a sufficiently potent force for the promotion of the general welfare, or indeed becomes a force which may actually injure the general welfare, the legislature may intervene and require that buildings intended for use as tenement houses or multiple dwellings shall conform to minimum standards which may reasonably be regarded as essential for safe, decent and sanitary dwelling places.

"The power of the state to place reasonable restrictions upon the use of property for the promotion of the general welfare is no longer subject to challenge.

"The object to be attained here is greater safety from fire and more sanitary conditions in tenement houses erected prior to 1901, and which do not even at this date conform to the standards set for all buildings erected since 1901.

"Because the state has tolerated slum dwellings in the past, it is not precluded from taking appropriate steps to end them in the future.

"When a building used as a dwelling house is unfit for that use and a source of danger to the community, the legislature in order to promote the general welfare may require its alteration, or require that its use for a purpose which injures the public be discontinued; and subject to reasonable limitations the legislature may determine what alterations should be required and what conditions may constitute a menace to the public welfare and call for remedy.

"The judgment should be affirmed with cost."

TELFORD'S MENAI SUSPENSION BRIDGE TO BE REBUILT

THE FAMOUS chain suspension bridge over Menai Straits, Scotland, built in 1826 by Thomas Telford, is to be modernized for modern traffic according to an announcement of the British Ministry of Transport. Damaged by a gale a year ago, the bridge was repaired so as to be serviceable but in the meantime Sir Alexander Gibb and partners, consulting engineers, were ordered to report on the condition of the bridge and the possibilities of rendering it fit for modern traffic. The reconstruction while retaining the essential features of the original design, would enable all modern types of traffic to use the bridge. At present the limit of weight is 4 1/2 tons. Also, pedestrians are compelled to use the roadway. Further dangers occur because the arches in the towers obstruct drainage vision. The new design will not disturb the existing masonry to any extent but a smaller number of suspension chains (there are now 16) will be provided and sidewalks will be built outside the suspenders. The towers will be slightly altered and the archways enlarged. The estimated cost exceeds one million dollars.

Grand Coulee Contractors Carry Tax Suit to Supreme Court

The U.S. Supreme Court has been asked to review a state court ruling imposing a 0.5 per cent state occupation tax on contractors building the Grand Coulee Dam. Two appeals have been filed, one by the Mason-Walsh-Atkinson-Kerr Co. and associates, the other by David H. Ryan, who was engaged on preliminary excavation and the construction of a railroad spur. The constructors argued that they are not subject to the state tax because they are engaged in work for the federal government on land taken over by it.

Bids for Transmission Line Called on Seattle's Ruby Dam

The Seattle, Wash., board of public works last week called for bids on two units of its $8,000,000 Ruby dam hydroelectric project.

Proposals will be received April 1 for construction of a $1,400,000 transmission line and on March 25 for clearing a portion of the reservoir basin at an estimated cost of $50,000. The transmission line, from New Halem to the city's south substation, will be 116 miles long and will be supported on 560 galvanized steel towers. Tower foundations have been constructed by WPA crews.

This is the second time that Seattle has asked for bids on clearing of the reservoir basin. Morrison-Knudson Co. of Boise, Idaho, submitted the low bid of $583,000 at the first opening Jan. 14. Since then, the plans have been revised, and the present contract calls for clearing only a portion of the entire area.

The first major contracts on the program were awarded early this month, when eight contracts totaling $480,000 were placed with four firms for electrical equipment.

Flood Control to be Dropped As CCC Activity

Restriction of future Civilian Conservation Corps activities to reforestation and conservation projects will be the result of the contemplated reduction in strength from 350,000 to 300,000 members. The new policy came to light with the announcement that plans have been abandoned to transfer 2,100 men to southern New York to work on flood control reservoirs at Arkport and Whitney Point. CCC Director Fechner pointed out that the President's announced plans for a permanent CCC organization limit the enrollment to 300,000 in 1,456 camps. The present strength is 350,000 in 2,082 camps. By April 1 it is expected that 82 camps in sections where work programs have been completed will be abandoned.

Waterworks Flood Lessons To Be Reviewed by A.W.W.A.

A comprehensive review of the recent Ohio River flood conditions, and of the lessons learned and work to be done as a result of them, is to form an important feature of the program at the annual convention of the American Water Works Association, to be held at Buffalo, N. Y., June 7-11, 1937.

The session on the Ohio River flood is to be followed by another discussion dealing with the organization and planning of waterworks for major catastrophes such as cities may experience in time of floods, conflagrations, or earthquakes.

Individual Negotiation Replaces Fixed Grant on PWA Project

Announcement of the Public Works Administration of three new allotments, all of which are subject to differing conditions, confirms the belief that the 45 per cent grant system has been abandoned for a policy of individual negotiation between the local sponsor and PWA. Recent allotments include the following:

The state of Kentucky will be granted the entire cost of certified relief labor up to a total of $1,800,000 employed in building two institutions: a correction penitentiary to replace the old Frankfort Penitentiary drowned out in the recent flood and to be built near La Grange at a total cost of $1,850,000, and an asylum and hospital in Boyle county to cost $2,150,000. In addition, the state will receive a flat grant of $300,000 from unexpended flood relief funds provided by the 1936 relief appropriation act.

The state of Colorado has been granted $3,000,000 to apply on a highway program. The balance of the cost will be met by a state bond issue. In 1933 Colorado was allotted $8,550,000 for this purpose, but this was later rescinded after a test suit had invalidated the bonds which the state had intended to issue as its share of the program. Since then the state constitution has been amended and the new bond issue upheld in a second test.

The city of Jacksonville, Fla., will be granted an amount equal to 115 per cent of the wages of the relief labor employed in building a $1,654,000 steel and concrete highway bridge across the St. Johns river at the foot of Main Street but not to exceed $293,250 in all. This amount was calculated after a survey of available relief labor in the area, which determined that 100 per cent of the unskilled, 60 per cent of the semi-skilled, and 40 per cent of the skilled and 60 per cent of the supervisory and professional labor needed on the project can be secured from relief rolls. The city's share of the cost will be provided by bonds to be sold privately.

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Injunction Change Arranged For Texas Projects

Modifications in a standing injunction have been agreed upon which will permit the continuation of construction on a number of dams being built by the Lower Colorado River Authority of Texas and by the Brazos River Conservation District in the same state. The injunctions were secured by seven Texas utility companies.

Under the terms of the modified injunction the public agencies are permitted to complete the Buchanan dam, (formerly Hamilton dam), and purchase and install electrical generating equipment; complete Inks Dam (also known as Arnold Dam) and purchase, but not install, generating equipment; construct Marshall Ford Dam; expend $200,000 to repair Austin Dam; proceed with construction of the Brazos River project, which does not at present contemplate power development.

The Lower Colorado development is financed by PWA; the Brazos River project by WPA.

Washington Highlights

PRESIDENT ROOSEVELT on March 11 signed an act extending the time for starting and completing construction of a bridge across the Missouri river near Brownville, Neb., and a second act declaring Turtle Bay and Turtle Bayou, in Chambers County, Texas, to be non-navigable waterways.

THE CONVERSATIONS held between President Roosevelt and Prime Minister Mackenzie King of Canada touched upon the St. Lawrence waterway, according to the President, who stated that the proposal is still in the preliminary study stage. He declined to state whether a treaty would be ready for submission to the Senate for ratification during the present session. The President also hinted that the Passamaquoddy project might possibly be coupled with the St. Lawrence development although he said that this had not been discussed with the Prime Minister.

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Santee-Cooper Hydro Project Hearings Begin

Hearings started March 8 in the U. S. District Court at Columbia, S. C. on the suit of the Carolina Power & Light Co., South Carolina Power Co., and Broad River Power Co. to block PWA financing for the Santee-Cooper hydro-electric project of the South Carolina Public Service Authority. As in some 50 other cases now pending, the issue raised is whether the federal government has authority to give financial aid to local authorities in developing publicly owned power.

Two days earlier, the Federal Power Commission extended to Dec. 31, 1941, the time limit for completing construction on the initial stage of the project. The extension was based on a finding that actual construction had been begun but that the work had been delayed because of litigation and other factors beyond the control of the licensee. The license is held by the Columbia Railway & Navigation Co., which has contracted to turn the project over to a public agency.

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Appeals Court Denies Payment For Extra Work

The U. S. Circuit Court of Appeals in a decision overruling a decision of the federal district court at Louisville has denied the claim of A. A. Davis & Co., of Oklahoma City, for extra payment of $77,680 on a sewer contract for Louisville, Ky.

The Davis Co. has sued the commissioner of sewage of the city of Louisville, Ky. for $77,680, claiming that this amount was due it because in building the Highland Park-Beechmont sewer the contractor found, after starting the work, that he was forced to remove rocks and other debris in connection with the earth excavation.

The district court had allowed the claim, but the Appeals Court held that the contractor had had ample opportunity to investigate the ground before taking the contract and awarded him only $2,586.

Study of Cabinet Gorge Hydro Project Approved by House

By a vote of 202 to 137, the House of Representatives on March 10 passed a bill authorizing the Secretary of the Interior to investigate the feasibility and economic usefulness of a proposed hydro-electri development at the Cabinet Gorge site on the Clark Fork of the Columbia River near the Montana-Idaho border. At the suggestion of Secretary Ickes, the bill was first amended to eliminate inclusion of the Rathdrum Prairie reclamation project in Idaho, already investigated and found to be infeasable for economic reasons.

The Cabinet Gorge project comprises a storage dam, reservoir, and hydro-electric generating installation. Its proponents argued that it is necessary to save from abandonment several private irrigation areas on which the water supply is rapidly failing, some of which date back to 1900. This would be effected through the storage of additional water and the generation of low-cost current for irrigation pumping. The possibility of developing markets for surplus power will also be investigated. An appropriation of $25,000 was included in the bill to cover the cost of the study, such money to be taken from receipts of the Reclamation Bureau.

An unsuccessful attempt was made on the floor of the House to amend the bill to transfer the investigation to the Corps of Engineers.

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Crossing Elimination Project Advertised for Bids

Bids on the first section of the $5,000,000 Elizabethport grade elimination project at Elizabeth, N. J., have been called for March 22 by the chief engineer, Central Railroad Co. of New Jersey, Jersey City terminal.

The Elizabethport elimination project is estimated to cost a little more than $5,000,000. It involves elimination of 13 grade crossings, requiring the construction of 21 railroad bridges and a large amount of grade revision and track construction on the railroad.

The present advertisement is for bridges and highway depressions from Livingston St. to First Ave. in Elizabeth, N. J. Bids are to be opened immediately on the closing of the bidding period March 22.

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PWA Approves Funds for More Study of Buzzard's Roost

The Public Works Administration has approved a requisition for $150,000 to be used on preliminary work for the Buzzards Roost hydro-electric project of Greenwood County, S. C. The amount will be charged against a $2,852,000 allotment made two years ago but since tied up by a suit brought by the Duke Power Co. Terms of the injunction permit the expenditure of not more than $150,000 for legal, administrative, conservation and engineering costs before a final decision is reached. The approval of funds permits this preliminary work to go ahead.

Huge Tin Plate Mill Opened By Republic in Niles, Ohio

FOLLOWING unusually rapid construction, Republic Steel Corp. opened its new tin plate mill at Niles, Ohio, to regular production on March 11. In four months from the time excavation was begun, new buildings covering 123,000 sq.ft. of floor space and reconditioned buildings of 177,000 sq.ft. area, together with all machinery, were ready for use. Some 1,300 tons of structural steel, 15,000 cu.yd. of concrete and 11,600 ft. of concrete piles were required in the new plant which has a pickling and finishing capacity of some 6,000 tons per month and a roll capacity of twice that amount.

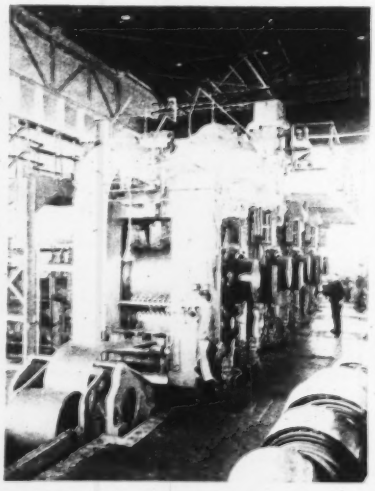
Although involving no special or unique structural details or construction problems, the new mill represents one of the large industrial building projects of the times. In operation it is characterized by a silence and a cleanliness seldom associated with steel making. Conventional mill-type buildings are used, with corrugated steel roofs and walls of steel sash and corrugated steel sheets. A timber roof is used in the pickling building to reduce corrosion hazards and eliminate painting expense. The motor room, where uniform temperature conditions are maintained with washed circulated air, is lined with buff, glazed tile; the outer walls are brick. Floors are of wood block wherever the steel strip can contact them; elsewhere concrete is used.

One of country's largest

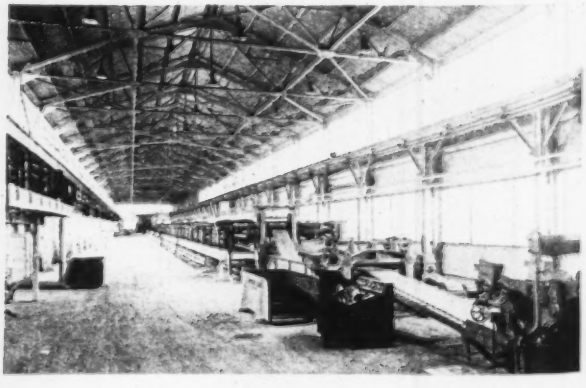
According to Charles M. White, vice-president in charge of operations of the Republic Steel Corp., the Niles mill is one of the largest strip tin plate plants in the country. Hot-strip coils obtained from the company's Warren plant are first run through a continuous pickler at a speed of 150 ft. per min., then cold reduced at 3,500 ft. per min. in a 4-stand mill having rolls 18 and 49 in. in diameter with a 42 in. face. Electro cleaning and cutting are followed by box annealing and more cold rolling and pickling before the sheets enter the tinning bath and final cleaning machine. Assorting and boxing follow in an air conditioned mill building.

According to Mr. White the tin plate mill is one of three large new operating units that will see service this year. In South Chicago a new wire mill will be officially opened in April while in Cleveland steel erection has just begun on 21 acres of buildings that will house finishing facilities for sheet up to 92 in. wide. The 98-in. rolls of the Cleveland mill will be the largest in existence when the plant opens in the fall.

The Republic engineering department, C. Joe Duby, chief engineer, Youngstown-Warren District, designed the Niles mill. Heller-Murray Co., Youngstown were contractors on the foundations, the Ohio Structural Steel Co. fabricated the framework which was erected by the Hunter Construction Co., Youngstown.



MODERN TIN PLATE manufacture as exemplified in Republic's new Niles, Ohio plant influences mill building design. Glazed tile walls in air-conditioned motor room, left below. Right, four-stand reducing rolls which increase head room and foundation requirements. Below right, continuous pickler whose covered top keeps acid fumes from corroding the steel in the building.



Bids for Sardis Dam Opened

Six bids were opened on March 9 at U. S. Engineers Office at Vicksburg, Miss., for the construction of the third largest earthfill dam in the world to be located at Sardis, Miss. The low bid was the General Construction Co., Seattle, Wash., at $3,976,926. The second low bid was by the Atlas Construction Co., Dallas, and Boyce & Igo of Baton Rouge, $3,985,477. The Sardis Dam is surpassed in size only by the Gatun Dam in Panama and the Fort Peck Dam in Montana. It will contain 14,000,000 cu.yd. of fill.

The dam is to be located on the Little Tallahatchie River, designed to control floods on that stream, and at the same time to provide a stable flow of water into the Yazoo River. Construction of the project calls for a spillway and outlet works to regulate the flow; these two projects are in addition to the construction of the dam. The reservoir, covering 58,000 acres will have a storage for flood control of 1,490,000 acre feet.

TVA Refutes Statements On Dams and Flood Damage

The Tennessee Valley Authority has refuted statements appearing in the daily press to the effect that rainfall was normal in the Tennessee Valley during January, 1937. The Authority made public figures showing that during that month, when serious floods occurred on the Ohio River, approximately three times the normal rainfall was recorded in the area above Norris Dam on the Clinch River, and at the same time more than 23 in. fell along the stretches of the lower Tennessee River. Normal rainfall for January in the latter region is 5.4 in.

During January the Norris Dam stored more than a million and a quarter acre-feet of water, and during the critical 15-day period, when levees on the lower Ohio River were being held by inches, the two completed dams of the TVA's proposed nine withheld 32,000 cu.ft. of water per second from the flood stricken area.

Norris Dam was operated in a flood control capacity last year, lopping almost 4 ft. off the flood crest that swept down on Chattanooga on Mar. 30, 1936. It is estimated by TVA that floodwaters at that time would have raised the Tennessee from a 37.1 ft. stage to 41 ft., with a consequent flooding of 1,000 urban acres.

Income Tax Decision Favors City Employees

The U. S. Supreme Court in a 7-2 decision on Mar. 15 ruled that New York City's water supply is an essential governmental function and therefore the federal government cannot collect an income tax on the salary of the chief engineer.

The case was brought to the court by W. W. Brush, formerly chief engineer of the Department of Water Supply, Gas and Electricity in New York. Although the decision was confined to this one case, it is felt that the principle may affect the federal tax status of some 200,000 employees in various branches of municipal government.

Previous to the Supreme Court findings, Mr. Brush had received adverse decisions from the Board of Tax Appeals and the Second Court of Appeals. His case was based on a federal tax levy of $256.27 made in 1931 on his $14,000 salary.

Sewage Equipment Contract Awarded in Buffalo

Contract for dewatering equipment at Buffalo's new Bird Island sewage treatment plant was awarded by the Buffalo Sewer Authority on March 5 to the Filtration Equipment Corp. of New York City on its bids of $74,900. The dewatering machinery is of the vacuum filter type, involving the use of three revolving cylinders, each 11 ft. 6 in. in diameter and 14 ft. long. The sewage will be filtered through screens and felt cloth, removing from 25 to 30 per cent of the water from the sludge; sludge emerging from the dewatering equipment is deposited on conveyors and carried to incinerators.

Greeley & Hansen, engineers for the sewer authority, will make a further study of the bids submitted on the incinerator unit before the contract is awarded. Bids have been submitted by the Nichols Engineering & Research Corp., $298,750; Underpinning & Foundation Co., $328,000; F. H. McGraw & Co., $258,000.

Bids on structures to house this equipment will be sought later since the design will be determined by the character of the equipment selected.

Two More Buildings Added to Williamsburg Housing Project

Bids have been requested by the Public Works Administration for two additional buildings for Williamsburg Houses, the slum clearance housing project in Brooklyn, N. Y. Contract for only 18 of the required 20 buildings were let last August because title to the remainder of the land had not yet been cleared. The two new buildings will add 151 dwelling units to the project increasing the total number to 1,622. This will be the largest public housing project in the United States. Superstructure erection is under way on the first 18 buildings by Starrett Bros. & Eken, the contractor. It is estimated by the P.W.A. Housing Division that work on the two extra buildings can be speeded up so that they will be completed by the same time the original 18 have been finished.

Flood Control Talk Continues Active

St. Louis conference last week unifies views of twenty-three state representatives

Discussion of plans and projects to minimize future flood disasters occupied the attention of engineers and public officials in the Ohio and Mississippi basins last week. A conference of representatives from twenty-three states was held in St. Louis, and in Pennsylvania a flood land condemnation bill was introduced in the legislature; at Cincinnati a program of placing flood lands to other uses was suggested. Towns in Indiana and Kentucky considered plans to move uphill from river-edge locations.

The conference in St. Louis, attended by 300 people, adopted resolutions urging Congress to appropriate funds for construction of control projects already made possible by the acts of the prior Congress; to amend the Overton and Copeland-Wilson acts; and to remove requirements for local contributions for flood control projects of an interstate or national character. Another resolution called on Congress to enlarge its program for flood-control in the light of the recent Ohio Valley disaster.

Major-General E. M. Markham, Chief of the U. S. Army Engineers, stated at the St. Louis conference that a flood control program costing about $750,000,000 would effectively harness high waters of the Mississippi and Ohio Rivers. General Markham said that this program called for the construction of 88 new reservoirs to cost $602,000,000, and dikes and walls to cost $190,000,000.

No dikes at Cincinnati

In lieu of proposed systems of diking, a long-range program of placing flood areas to uses other than those of the present was suggested at a meeting of the Cincinnatus Association. Herbert Schroth, chairman of the committee on flood control of the association, said that the suggestion was based on a decided trend in professional opinion toward the theory of letting rivers have their just due and to stop efforts to confine them. He pointed out that because of the rugged topography of Cincinnati and the comparatively narrow flood plain, restriction on homes and buildings in the flooded area would not work any great hardship.

Governor Earle of Pennsylvania approved legislation on March 10 authorizing the state to condemn land needed for flood-control works and to use the dams to generate power in competition with utilities. The bill passed the House, but a bloc in the Senate protested the power clause. They contended manufacture of power was not related to flood control. A companion bill is pending in the Senate to appropriate $8,000,000 for flood control projects.

Leavenworth, Ind., (350 pop.) and Uniontown, Ky., (1,235 pop.) took definite steps toward removing to higher locations. Leavenworth has been offered a nearby estate far above the river as a new site. A vote taken in Uniontown showed that 95 per cent of the population was in favor of moving away from the river banks.

Mayors of Eastern Cities Ask Two Billions from Congress

Meeting in Philadelphia on March 13, the mayors of 20 Eastern cities resolved that all of their 2,800,000 persons on WPA rolls must continue to be supported by the federal government. They voted to ask Congress to appropriate a minimum of $2,200,000 to carry on the WPA for the 1937-1938 fiscal year. Mayor F. H. LaGuardia, of New York, delivered the keynote address, and according to news accounts only Mayor George Quigley of New Britain, Conn. dissented from the general attitude of dependence upon the federal government. He saw in it a possibility that cities and perhaps states would lose their identity. Mayor George E. Brunner of Camden, N. J., urged that the WPA be made a permanent organization.

New York Wins Award for Traffic Safety

New York City was awarded the grand prize for the city doing the most in 1936 to reduce street traffic accidents in a contest conducted by the National Safety Council. New York also ranked first among the thirteen cities of more than 500,000 population. Winners in other population groups were: Kansas City, Mo., 250,000 to 500,000; Omaha, Neb., 100,000 to 250,000; Jackson, Mich., 50,000 to 100,000; West New York, N. J., 25,000 to 50,000; and Wilmette, Ill., 10,000 to 25,000. A special honor roll for cities between 5,000 and 10,000 population that passed the year without a single traffic fatality carries a list of 139 towns.

Thos. H. MacDonald, chief, U. S. Bureau of Public Roads, was chairman of the committee of judges. Scoring was based on reduction of death rate over the average of the previous three years, a low death rate, safe traffic planning and construction, traffic law enforcement and public educational campaigns.

New Company Formed to Sell Building Glass

Two of America's leading glass manufacturers—Pittsburgh Plate Glass Co. and the Corning Glass Works—have formed a new company to be known as the Pittsburgh-Corning Corp., to manufacture and sell glass products used in the building field. The many other fields in which the two companies are active are in no way affected by the formation of the new company which does not represent a merger of the two corporations. The Pittsburgh-Corning Corp. will supply such products as glass block, glass tile, colored structural glass and molded glass—products which are used in the construction of houses, factories, office buildings and store fronts. The Pittsburgh Plate Glass Co. has 70 warehouses throughout the United States serving the building industry with window glass, plate glass, etc., while Corning has been unusually active in the development of glass brick, blocks, and other glass products. Thus the technical developments of the Corning laboratory will be supplemented by the wide distribution facilities of Pittsburgh Plate Glass Co.

Utah, Idaho, Wyoming to Study Green and Bear River Project

A compact for a preliminary study of the proposed Green River-Bear River diversion, which is expected to lead ultimately to the construction of an irrigation and power project of large size, has been agreed upon by Utah, Idaho and Wyoming. T. H. Humphreys, state engineer of Utah, John D. Quinn, state engineer of Wyoming, and Robert W. Faris, Idaho state commission of reclamation, have signed the compact which provides for $2,000 contributions from each of the states matched by $6,000 from the U. S. Bureau of Reclamation. Later the Bureau of Reclamation expects to make a more detailed study for which $20,000 is said to have been budgeted.

The project contemplates a dam on the Green River 12 miles above Daniels, Wyo., to store 300,000 acre-ft. Conduits some 60 miles long would carry water from this dam to the head of Twin Creek in Wyoming whence it would flow naturally into the Bear River to supplement the natural flow. The natural flow of the Bear River would be stored in Coyote reservoir and two other reservoirs. Irrigation water would be provided for some 135,000 acres in Utah, 50,000 in Idaho, and 65,000 in Wyoming.

Prof. Elihu Thomson Dies, Founder of General Electric Co.

Professor Elihu Thomson, 83, dean of American scientists and one of the founders of the General Electric Co., died at his home in Swampscott, Mass., March 13. He had been seriously ill since January. Professor Thomson, with Thomas A. Edison, James J. Wood, and Charles F. Brush were pioneers in the modern electrical industry. The professor's technical work was directly reflected in practical developments, as he was one of the early arc-light inventors, and experimented with the principle of alternating-current transmission far in advance of commercial demands. He held upward of 700 patents in the United States alone.

He originated the resistance method of electric welding, which has been in continuous use from 1887 to the present time; developed the repulsion type of induction electric motor; invented the magnetic blowout principle in lightning arresters and electric switches, the oil-cooled type of transformer, the constant-current transformer, and the modern process of commercially treating fused quartz.

San Francisco Turns Down Municipal Power Plant

The voters of San Francisco on March 10 defeated by about 12,000 votes the proposal to issue $50,000,000 worth of bonds to purchase the Pacific Gas & Electric Co., local distribution system and to build a new city power plant. About two-thirds of the power requirements of the city are supplied by the private company with the remainder coming from San Francisco's Hetch Hetchy project.

Alfred D. Flinn, Director of Engineering Foundation, Dies

The death on March 14 of Alfred D. Flinn, director, Engineering Foundation, brought to an end a career of exceptional engineering accomplishment encompassing in the first half of his life water supply development and technical journalism and in the latter half administration of the research activities of the four national engineering societies. Dr. Flinn was 68 years old and his death, caused by heart disease, followed a prolonged illness.

Alfred D. Flinn

After graduation in 1893 from Worcester Polytechnic Institute with the degree of bachelor of science in civil engineering, he took post graduate work at the Massachusetts Institute of Technology and thereafter, until 1902, held various positions in the waterworks departments of Boston and other Massachusetts cities. This work comprised the Wachusett and Sudbury systems of additional supply for more than 20 communities.

From 1902 to 1904 Dr. Flinn served as managing editor of *Engineering Record*, one of the predecessor papers of *Engineering News-Record*. He then became general inspector for the Croton Aqueduct Commissioners, being in charge of their New York engineering office, and in August, 1905, became associated with the Board of Water Supply of the city of New York which he served until January, 1918. He was successively division engineer, department engineer of headquarters, deputy chief engineer, and on a number of occasions acting chief engineer. The work included semifinal and final engineering and economic studies for the development of the Catskill aqueduct system.

In January, 1918, Dr. Flinn was made secretary of the United Engineering Society, which was succeeded by the Engineering Foundation, research organization of the national engineering societies, and United Engineering Trustees, joint administrative agency of the four societies—American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, the American Society of Mechanical Engineers, and the American Institute of Electrical Engineers. He became director of the Foundation in 1...

In cooperation with the National Research Council, Dr. Flinn aided in developing and financing the fatigue of metals research, the arch dam investigation, the alloys of iron research, and many other enterprises. He was a fellow of the American Association for the Advancement of Science and a member of the American Society of Civil Engineers which he served as director from 1917 to 19... He represented the American Society of Civil Engineers on the Engineering Societies Library Board.

New Plant Started For Heat-Treatment of Rails

Following the completion and tuning up of the Brunorizing rail plant of the Carnegie-Illinois Steel Corp. at Gary, Ind., the formal opening was celebrated March 10 and March 15. On the first date railroad presidents, executives and newspaper representatives attended and on the latter some 500 members of the American Railway Engineering Association visited the plant.

Brunorizing, named for the late John Brunner, consists of normalizing or heat-treating steel railroad rails to improve their physical properties. The furnace at Gary is of the continuous type, gas-fired and thermostatically controlled. It is 252 ft. long and 9½ ft. wide inside, thus being able to hold six groups of eight 39-ft. rails at one time. The rails are carried on special alloy-iron heat-resisting rollers on which they are moved forward. As the time of reheating varies between 18 and 30 min., depending on rail section, new groups of rails enter the furnace at uniform intervals of 3 to 5 min. In the interval between full-length forward moves the rails in the furnace are constantly moved backward and forward several times a minute as the rollers oscillate through part of a revolution. This oscillation promotes more uniform heating and lessens any tendency of the rollers to sag at the operating temperatures. The furnace has eight zones for automatic heat control. The rails are heated uniformly throughout their full length reaching the desired temperature when about one-half way through thus allowing the other half for thorough equalization. Rails enter at 900 to 1,000 deg. F. and are raised to 1,525 to 1,550 deg., about 100 deg. above the critical range.

An end-hardening operation by air quenching is done as the rails leave the furnace. This treatment raises the Brinell hardness to 350 tapering off to the normal of 250 in about 3 in.

The Brunorizing treatment makes the grain finer, lessens internal stresses, increases toughness, makes possible uniform end hardening and improves ductility especially in cold weather.

John Brunner was metallurgical engineer for the Carnegie-Illinois Steel Co., and was a member of the committees on iron and steel structures and on track stresses of the A.R.E.A. He died last year.

Thousand Islands Bridge Bids Meet Engineers' Estimate

Bids received for construction of a bridge across the St. Lawrence River west of Alexandria Bay by the Thousand Islands Bridge Authority on March 10 totalled $2,011,460 as against the engineers' estimate of $2,001,000. The bridge will consist of three separate structures. The American crossing will be a suspension bridge with 800-ft. main span and 300-ft. side spans as well as long approaches. The so-called "international rift crossing" will consist of a 90-ft. span concrete rigid frame connecting Wells Island to Hill Island; it will be half on American soil and half on Canadian soil. The Canadian crossing will consist of a suspension bridge with a 750-ft. main span and 300-ft. side spans.

A total of 18 bids was received with low bidders as follows: American crossing substructure, Dominion Construction Corp. Ltd., Toronto, Ont., $297,673; American crossing superstructure, American Bridge Co., New York, $759,817; 90-ft. concrete rigid frame, R. A. Blyth, Toronto, Ont., $29,962; Canadian crossing substructure, Cameron & Phin, Welland, Ont., $117,378; and Canadian crossing superstructure, Canadian Bridge Co. Ltd., Walkerville, Ont., $896,628. Work is scheduled to begin May 1 with a completion date set for November 1938. The engineer for the Thousand Islands Bridge Authority is W. T. Field, Watertown, N. Y. Consulting engineers are Robinson & Steinman, New York, and Monsarrat & Pratley, Montreal.

Personals

EDWIN A. KRAEMER has been appointed by the Cincinnati Planning Commission to make a study of the city's river front.

HARRY J. COUGHLAN and ARTHUR C. COUGHLAN, formerly with the construction firm of J. J. Coughlan & Sons, have incorporated as the Coughlan Const. Co., Inc., Boston, Mass.

E. J. AUSIN, former city engineer of Hoquiam, Wash., has been appointed senior engineer for the national park service at Spokane, Wash.

C. A. THOMPSON, after twelve years with the Tennessee highway department, has joined the Ziegler Const. Co., of Nashville, Tenn., as superintendent of a highway construction project at Tupelo, Miss.

JOHN G. AHLERS, formerly partner in the New York building firm of Barney-Ahlers Const. Corp., and WALTER T. FITZPATRICK have joined Fred T. Ley & Co., Inc., contractor of New York and Springfield, Mass., as vice-presidents.

E. M. FLEMING, district manager for the Portland Cement Association in New York, has been named regional manager of eastern offices for the Association with headquarters in New York, to replace J. R. FAIRMAN, recently named assistant to the vice-president, Penn-Dixie Cement Corp.

Sphere and Obelisk to Comprise New York Fair Theme Building

THE DOMINANT architectural feature of the New York World's Fair will be a spherical building 200 ft. in diameter adjacent to a 700-ft. triangular obelisk which will contain the entrance and exit facilities for the sphere, whose only door will be 50 ft. above the ground. At this level the sphere and obelisk will be connected by a bridge. Inside the sphere, the visitor will step onto a circular moving platform from which he will look down on a panorama of "the world of tomorrow," while above him will be the sky and clouds on the sphere shell.

Designed to exemplify the theme of the fair—Building the World of Tomorrow—this unusual structure was planned by the architectural firm of Harrison & Fouilhoux, for whom Weiskopf & Pickworth acted as consultants on the structural design features. The estimated cost of the two structures is $1,200,000. The framework for them will be of structural steel and the surface covering will be "some white substance," whose nature is as yet undetermined. In announcing the theme building, Grover Whalen, president of the Fair Corporation, stated that "We do not mean that the buildings of tomorrow will be spheres and triangles, but we do believe that they will shed extraneous elements and revert to fundamental lines and forms."

The sphere, exclusive of exhibit material, will weigh about 2,900 tons, and will be supported on eight columns spaced around a circle 81 ft. in diameter. Each column will be 12 ft. high and will be covered with a cylindrical jacket. The columns will be hidden by fountains and water jets upon which the sphere will appear to float. The water will fall back into a 3-ft. deep circular pool which will be 8 ft. below the bottom of the sphere. In addition to its outer covering the sphere will have an inner shell perforated to absorb sound. Insulation will be applied to the inner surface of the outer shell. The space between the two shells will be 4 ft. at the top and 16 ft. at the bottom, where the ventilating and air conditioning equipment will be installed.

The obelisk will measure 68 ft. on a side at the base, and each of its three sides will be triangles tapering to a point at a height of about 700 ft. Within it two escalators will rise 65 ft. to the sphere bridge. On the opposite side of the obelisk, a ramp 900 ft. long will slope down from the sphere exit curving around the fountain base beneath the sphere in a three-quarter circle.

The theme exhibit is being designed by Henry Dreyfuss. Foundation work for the theme building is expected to begin in May. Construction will be supervised by W. Earle Andrews, general manager of the Fair, and John P. Hogan, chief engineer, as well as by the board of design, composed of Stephen F. Voorhees, chairman, Robert D. Kohn, Walter Dorwin Teague, Robert H. Schreve, William A. Delano, Gilmore D. Clarke and Jay Downer.

Dykstra to Leave Cincinnati for University of Wisconsin

C. A. Dykstra, city manager of Cincinnati since 1930, has resigned his post to accept the presidency of the University of Wisconsin as the successor to Dr. Glenn Frank. Mr. Dykstra's unusually successful term of office in Cincinnati was preceded by many years of experience in municipal administration work and the teaching of political economy. He thus combines wide training in administrative work with a fine background of educational service.

Mr. Dykstra graduated from the University of Iowa in 1903 and was an assistant in political science at the University of Chicago in 1904, an instructor in history and government at Ohio State in 1907-09, and professor of political science and head of that department at the University of Kansas from 1909 to 1918. He then became executive secretary of the Cleveland Civic League, two years later secretary of the Chicago Civic Club, and from 1922 to 1926 was secretary of the Los Angeles Civic Club. He also served Los Angeles as commissioner of the department of water and power and director of personnel efficiency and was professor of municipal administration at the University of California.

Obituary

L. W. KINLEY, engineer of Clarke County, Ia., for the last five years died Mar. 3 following an automobile accident.

TIMOTHY J. REARDON, engineer for the Cincinnati, Hamilton & Dayton and Big Four railroads died recently in Cleveland, Ohio.

JAMES E. WILLIAMSON, consulting hydraulic engineer of New York City died suddenly on Mar. 8 enroute to his home in Maplewood, N. J. He was 64 years old.

MARTIN X. WISDA, designing engineer in the bureau of bridges of the Ohio state highway department for the past eleven years, died at his home in Canton, O., at the age of 47.

FRANK B. FOLLETT, for the past 32 years president of the F. M. Ballou Co., contractor of Providence, R. I., died at his home in that city recently. He was a graduate of Brown University.

HENRY C. HELT, construction engineer, Evanston, Ill., and for twelve years with the Bucyrus-Erie Co., died Mar. 8 at the age of 42. A graduate of the University of Illinois, he served as construction engineer on the Panama Canal and the Rock Island arsenal.

ALPHONSE LAFLECHE, assistant chief engineer of the St. Lawrence Ship Channel staff of the Department of Transport,

Canada, died in Montreal on Mar. 8. A native of St. Martin, P. Que., Mr. Lafleche graduated from l'Ecole Polytechnique, Montreal, in 1909. Entering the federal government service in 1911, he remained with the civil service until hs death. Most of his experience was with the ship channel branch of the government's engineering work, and he was a member of the inter-departmental committee which has been considering the question of water levels in the St. Lawrence.

LEWIS M. HAUPT, professor and consulting engineer, died at his home in Cynwood, Pa., on Mar. 10 at the age of 92. He was born at Gettysburg, Pa., and graduated from West Point in 1867. After several years of railroad, educational and public improvement work, he became professor of civil engineering at the University of Pennsylvania in 1875. In 1892 he left teaching to open up a consulting office in Philadelphia. He was the first president of the Philadelphia Engineers Club.

PAUL E. GREEN, president of Marr, Green & Opper, consulting engineers of Chicago, died on Mar. 12. Born in Richmond, Ind., in 1879, he graduated from the University of West Virginia and gained his early experience with several railroads. At one time he was associated with the city of Chicago in general charge of work on the North Side for the Board of Local Improvements. He formed his consulting firm in 1908, and served more than 100 cities in the Middle West. During the War he was district engineer for the U. S. Housing Bureau, and lately has held several advisory and consulting positions with the federal government.

SOCIETY CALENDAR

AMERICAN SOCIETY OF CIVIL ENGINEERS, spring meeting, San Antonio, Texas, April 21–24.

NATIONAL RIVERS AND HARBORS CONGRESS, annual convention, Washington, D.C., Apr. 26-27.

AMERICAN WATER WORKS ASSOCIATION, INDIANA SECTION, Indianapolis, Ind., March 25–26.

AMERICAN WATER WORKS ASSOCIATION, FLORIDA SECTION, Ocala, Fla., March 30–April 1.

AMERICAN WATER WORKS ASSOCIATION, KENTUCKY-TENNESSEE SECTION, and SOUTHEASTERN SECTION, joint meeting, Chattanooga, Tenn., April 5–7.

GREATER NEW YORK SAFETY COUNCIL, annual convention, New York City, April 13–15.

AMERICAN WATER WORKS ASSOCIATION, CANADIAN SECTION, Montreal, Canada, April 14–16.

AMERICAN WATER WORKS ASSOCIATION, MONTANA SECTION, Lewiston, Mont., April 19–23.

AMERICAN WATER WORKS ASSOCIATION, FOUR STATES SECTION and PENNSYLVANIA WATER WORKS OPERATORS ASSOCIATION, joint meeting, Philadelphia, Pa., April 22–23.

AMERICAN WATER WORKS ASSOCIATION, ILLINOIS SECTION, Springfield, April 29–30.

NORTH CAROLINA INDUSTRIAL SAFETY CONFERENCE, Winston-Salem, May 20–21.

AMERICAN WATER WORKS ASSOCIATION, PACIFIC NORTHWEST SECTION, Victoria, B. C., May 20–22.

LARGER AWARDS FOR THE WEEK

Superstructure of bottling plant and distribution building, Sheffield Farms Company, New York, N. Y. $1,200,000

Substation for Pacific Gas and Electric Company, Oakland, Calif. $5,200,000

Packing plant, Armour and Company, Omaha, Nebr. $700,000

Apartment, 5 West 86th Street Corporation, New York, N. Y. $600,000

Apartment, Lelin Corp., New York $500,000

Hospital, Ypsilanti, Mich. $1,117,000

Junior high school, Sheboygan, Wis. $561,000

Buildings and docks at United States Army Air Corps Supply Depot, Sacramento, Calif. $1,200,000

Additional buildings, Veteran's Hospital, Los Angeles, Calif. $822,000

Highways, Missouri $628,000

High pressure wind tunnel for aeronautical experimental work, National Committee for Aeronautics, Hampton, Va. $1,000,000

INDEX NUMBER

ENR Cost	1913 = 100	1926 = 100	ENR Volume	1913 = 100
Mar., 1937	225.25	108.18	Feb., 1937	181
Feb., 1937	223.45	107.41	Jan., 1937	167
Mar., 1936	201.20	96.71	Feb., 1936	176
1936 (Av.)	206.46	99.24	1936 (Av.)	185
1935 (Av.)	195.22	93.84	1935 (Av.)	135
1934 (Av.)	198.10	95.23	1934 (Av.)	114

CONTRACTS

(Thousands of Dollars)

	Weekly Average Mar. 1936	Prev. 4 Weeks	Week Mar. 18 1937
Fed. Government	$1,985	$4,239	$5,340
State and Municipal	20,702	13,749	11,304
Total public	$22,687	$17,988	$16,644
Total private	14,237	28,999	17,925
Week's total	**$36,924**	**$46,987**	**$34,569**

Cumulative to date:
1936 (12 weeks) $568,132,000
1937 (11 weeks) $470,056,000

Note: *Engineering News-Record* reports waterworks and earthwork, reclamation or waterways projects of $15,000 and over in size; other public works, $25,000; industrial buildings, $40,000; other buildings, $150,000 and over. The figures above represent the volume of contracts and large force account projects throughout the U. S. that are of these minimum sizes or over.

NEW PRODUCTIVE CAPITAL

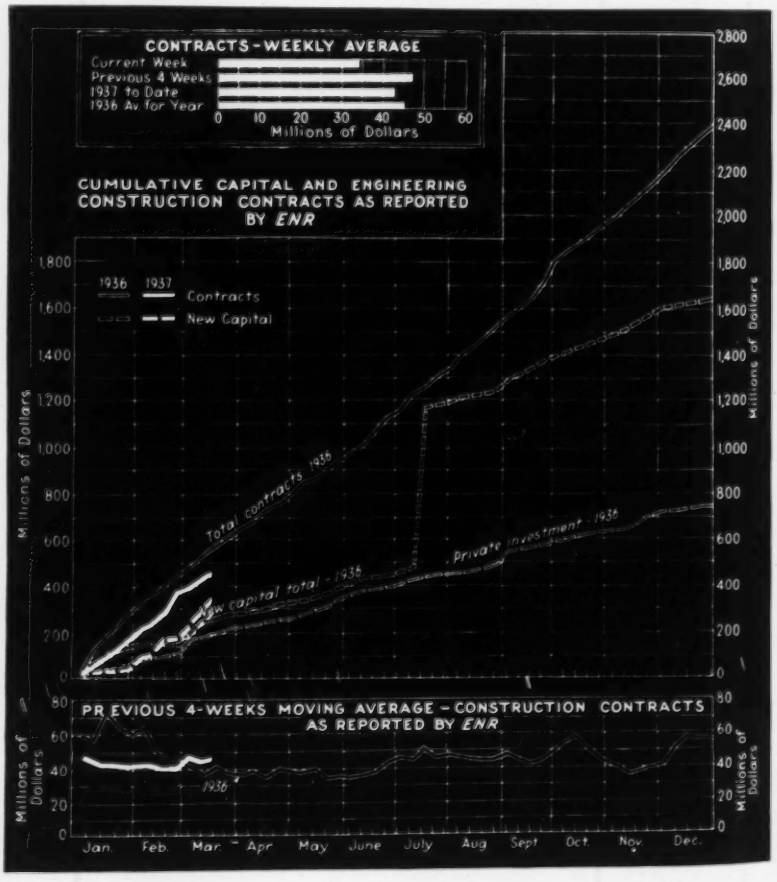
(Thousands of Dollars)

1937	Week Mar. 18	Cumulative
Private investment	**$54,001**	**$301,894**
State and municipal bonds	4,845	134,752
Corporate securities	49,156	167,142
Federal financing	**$5,393**	**$46,569**
PWA non-federal Projects	5,393	46,569
Total non-federal	**$59,394**	**$348,463**
Federal projects		
Total	**$59,394**	**$348,463**

Cumulative to date:
1936 (12 weeks) $282,574,000
1937 (11 weeks) $348,463,000

Note: These figures include private bonds and stocks sold for new construction purposes; state and municipal bonds for construction; PWA loans and grants to states and municipalities, RFC direct purchase of bonds for "self liquidating" projects, and 25 per cent of WPA construction appropriations.

† Includes transfer from federal to private investment financing through sale by RFC of PWA bonds.



Current Construction Unit Prices

Steel Pipeline, California

FIVE MILES of welded steel pipe line from 48 to 60 in. in diameter is being built by the San Francisco Public Utilities Commission, between Crystal Springs Dam and Burlingame. Bids were received in December, 1936. No quotations were received for the 57-in. steel-cylinder reinforced concrete pipe alternate. The unit prices and totals of the three low bidders are submitted in the following tabulation: (A) Williams Bros. & Haas, Inc., San Francisco, Cal., $643,939; (B) Emsco Derrick & Equipment Co., Los Angeles, Cal., $655,481; (C) R. G. Clifford, San Francisco, Cal., $655,990.

CRYSTAL SPRINGS PIPE LINE, CALIFORNIA

Item	A	B	C
1. Welded steel pipe, 60 x 5/16 in.—24,620 lin.ft.	$13.84	$11.71	$12.08
2. Welded steel pipe, 48 x 5/16 in.—345 lin.ft.	14.83	12.48	11.31
3. Welded steel pipe, 78 x 1/2 in.—660 lin.ft.	26.03	26.03	21.00
4. Special pipe, misc.—62,000 lb.	.15	.1075	.134
5. Bevelled courses, curved secs., 60 x 5/16 in.—530 each	35.00	49.30	30.00
6. Do. for 48 x 5/16 in. pipe—18 each	35.00	30.00	35.07
7. Welded steel standpipe, 60 x 5/16 in.—100 lin.ft.	15.00	33.24	13.47
8. Bitum. enamel pipe coating, lining—828,000 sq.ft.	.08	.0675	.04
9. Felt wrapping, steel pipe—397,000 sq.ft.	.04	.03125	.02
10. Couplings, 60 in.—7 each	80.00	91.41	151.03
10a. Couplings, 36 in.—2 each	40.00	48.92	89.03
10b. Couplings, 8 in.—2 each	9.00	9.20	19.75
11. Manholes on steel pipe—26 each	160.00	165.00	155.73
12. Saddle nozzles—4,500 lb.	.35	.37	.378
13. Steel companion flanges—17,000 lb.	.20	.235	.256
14. Misc. steel work on pipe—4,600 lb.	.25	.225	.25
15. Misc. steel work, unattached—49,000 lb.	.14	.165	.156
16. Gate valves, 6 in., 150 lb.—3 each	40.00	39.40	21.80
17. Gate valves, 6 in., 150 lb., bevel gears—19 each	90.00	76.45	84.40
18. Gate valves, 8 in., 150 lb.—18 each	67.00	56.10	62.01
19. Gate valves, 8 in., 150 lb., bevel gears—6 each	110.00	93.15	104.69
20. Gate valves, 12 in.—2 each	190.00	135.84	141.88
20a. Gate valves, 30 in.—2 each	1,400	1,275	1,646
20b. Gate Valves, 36 in.—2 each	1,800	1,650	1,646
21. Vacuum valves, 6 in.—19 each	200.00	147.00	164.49
22. Vacuum valves, 8 in.—5 each	290.00	215.00	270.71
23. Air release valves—24 each	45.00	41.00	41.91
24. Steel castings, tower—33,000 each	.25	.33	.20
25. Water meters, 8 in.—2 each	750.00	725.00	785.10
26. Cast iron pipe, valves, fittings—22,000 lb.	.15	.17	.217
27. Corr. metal pipe culverts—4,000 lb.	.15	.14	.156
28. Misc. steel castings—2,700 lb.	.25	.27	.306
29. Bolts, nuts, washers—6,000 lb.	.20	.22	.306
30. Install fittings on pipe—1,500 lb.	.12	.10	.139
31. Install gate valves, meter—160,000 lb.	.05	.07	.042
32. Install misc. metalwork—7,000 lb.	.06	.10	.128
33. Pipe trench excav. to 12 ft.—24,000 cu.yd.	1.50	2.00	3.50
34. Pipe trench excav. below 12 ft.—70 cu.yd.	2.00	3.00	5.00
35. Pipe trench excav. Cl. 2—37,000 cu.yd.	.70	1.44	1.20
36. Earth excav. footings, trenches—900 cu.yd.	1.20	2.00	2.50
37. Addit'l. rock excavation—400 cu.yd.	3.00	5.00	3.50
38. Bench excavation—8,400 cu.yd.	.60	.75	1.20
39. Earth embankments—250 cu.yd.	1.00	.50	1.00
40. Sand backfill—4,000 cu.yd.	1.00	2.70	1.50
41. Sewer laterals—60 each	20.00	20.00	20.00
42. Sewer pipe, 6 in.—300 lin.ft.	.75	1.72	.70
43. Concrete, Cl. A—260 cu.yd.	20.00	30.00	35.00
44. Concrete, Cl. B—190 cu.yd.	20.00	25.00	28.00
45. Cement—30 bbl.	2.50	4.00	3.00
46. Reinforcing steel—65,000 lb.	.06	.06	.07
47. Redwood timber—17 M.B.M.	100.00	100.00	110.00
48. Douglas fir timber—4 M.B.M.	70.00	70.00	90.00
49. Structural steel—15,300 lb.	.05	.10	.172
50. Misc. iron work—3,500 lb.	.12	.32	.22
51. Steel floor gratings—650 sq.ft.	1.20	4.00	2.01
52. Paint misc. structures—2,000 sq.yd.	.30	.30	.30
53. Drain tile, 6 in.—650 lin.ft.	.20	1.62	.70
54. Repavement—65,000 sq.ft.	.25	.35	.26
55. Build Venturi meter building—total	1,500	3,500	2,200

Concrete Reservoir, San Francisco

THE CONSTRUCTION of concrete lining, roof and control works for University Mound reservoir in San Francisco, Cal., is progressing under the jurisdiction of the Public Utilities Commission, N. A. Eckart, engineer. Contract was awarded on a lightweight concrete alternate for girders, joists and roof slab, and standard aggregates for other concrete work, at a saving of 4.1 per cent as compared with the use of standard weight concrete throughout. Five of the six bidders on standard concrete also submitted alternate bids on the light-weight construction, with a fairly uniform saving indicated by all for adoption of the latter type.

The following tabulation summarizes the principal unit bid items and totals of the two low bidders for the adopted alternative and of the low bidder for the standard weight concrete: (A) MacDonald & Kahn Co., Ltd., San Francisco, Cal. (contract), $692,916; (B) C. W. Caletti & Co., San Rafael, Cal., $693,891; (C) Clinton Construction Co., San Francisco, Cal. (alternate), $722,717.

UNIVERSITY MOUND RESERVOIR, SAN FRANCISCO

Item	A	B	C
1. Trim inner slopes, crest—15,000 sq.yd.	$0.34	$0.74	$0.64
2. Prepare reservoir bottom—total	4,500	9,000	6,300
3. Struct. excav. earth—2,000 cu.yd.	2.80	3.50	...
3a. Struct. excav. earth—1,880 cu.yd.	...	...	2.30
4. Struct. excav. rock—565 cu.yd.	4.60	5.00	...
4a. Struct. excav. rock—550 cu.yd.	...	...	5.00
5. Concrete, reservoir lining—11,840 cu.yd.	9.70	11.25	...
5a. Concrete, reservoir lining—11,440 cu.yd.	...	...	11.60
6. Concrete, inlet, outlet struct.—3,090 cu.yd.	16.40	17.90	...
6a. Concrete, inlet, outlet struct.—2,700 cu.yd.	...	...	19.20
7. Concrete, roof, joists, girders—9,430 cu.yd.	23.30	21.75	...
7a. Concrete, roof, joists, girders—9,000 cu.yd.	...	...	25.70
8. Concrete, retaining walls—80 cu.yd.	29.30	30.00	23.00
9. Concrete, spillway—160 cu.yd.	22.30	20.00	17.50
10. Concrete, subsurf. struct.—20 cu.yd.	18.80	25.00	18.50
11. Extra cement—400 bbl.	2.00	2.00	2.50
12. Reinforcing steel—3,500,000 lb.	.04	.04	...
12a. Reinforcing steel—3,200,000 lb.	...	...	.045
13. Welded wire fabric—55,000 sq.yd.	.50	.50	.53
14. Flexible couplings—1 each	130.00	200.00	100.00
15. Slide, flap gates—total	7,980	8,000	9,600
16. Water screen, centrif. pump—total	7,410	7,000	8,000
17. Cast steel fittings—25,000 lb.	.24	.20	.19
18. Cast iron fittings, pipe—10,000 lb.	.13	.10	.11
19. Pipe handrail, steel pipe—11,000 lb.	.25	.20	.20
20. Structural stee —75,000 lb.	.14	.11	.13
21. Misc. metal work—6,600 lb	.40	.25	.34
22. Install gate valves—62,000 lb.	.035	.03	.01
23. Install cast iron b. & s. pipe—74,000 lb.	.035	.01	.02
24. W.S. pipe, 60 x 5/16 in.—1,475 lin.ft.	17.80	16.00	18.00
25. Steel pipe specials—27,000 lb.	.27	.22	.24
26. Bevelled courses, curved pipe—35 each	40.00	70.00	60.00
27. Bitum. enamel coating, lining—50,000 sq. ft.	.12	.12	.13
28. Felt wrapping, steel pipe—16,000 sq.ft.	.045	.05	.05
29. Excav. backfill, earth trench—2,600 cu.yd.	40.00	1.00	.70
30. Excav. backfill, rock trench—1,700 cu.yd.	1.00	3.00	1.50
31. Sand backfill—600 cu.yd.	1.70	2.00	1.20
32. Repavement—450 sq.ft.	.30	.40	.30
33. Regrade, subgrade, Bacon St.—800 cu.yd.	1.20	1.50	.85
34. Pave Bacon St.—22,500 sq.ft.	.24	.20	.25
35. Concrete sidewalk—8,500 sq.ft.	.18	.15	.17
36. Curb and gutter—1,750 lin.ft.	.90	1.25	1.00
37. Reinf. conc. pipe, 30 in.—40 lin.ft.	11.50	3.00	16.00
38. Grout holes—200 lin.ft.	2.85	1.50	6.00
39. Grout—200 sack cement	1.15	1.00	3.50

Dam 17, Mississippi River

A DAM to include eight 64x20-ft. tainter gates, three 100x20-ft. roller gates, a 200-ft. storage yard, 1,555 ft. of submersible earth dike, and 520 ft. of non-overflow earth dike to make the overall length 3,196 ft. will be built across the upper Mississippi River 4 mi. above New Boston, Ill., as Dam No. 17 of the 9-ft. canalization program. Plans were prepared by U. S. Army Engineers of the Rock Island District and the work must be completed within 730 calendar days after contractor is notified to proceed. Minimum hourly wage rates are to vary from $1.25 for plasterers to 50c for common laborers. On Jan. 19, 1937 eight bids were opened for the work and the difference between the highest and lowest bids was $267,786. (A) The Maxon Const. Co., Dayton, Ohio, (contract)

$2,281,042; (B) United Const. Co., Winona, Minn., $2,285,849; (C) The Massman Const. Co., Kansas City, Mo., $2,318,636—unit prices of the three lowest bidders follows:

DAM NO. 17, MISSISSIPPI RIVER

Item	A	B	C
1. Cofferdam—1,057.83 lin.ft.	$288.00	$282.00	$310.00
2. Clearing—job	1,000	5,657	5,000
3. Common excavation—85,000 cu.yd.	.20	.20	.50
4. Dredged excavation—200,000 cu.yd.	.20	.185	.25
5. Top soil excavation—27,500 cu.yd.	.40	.40	.33
6. Common fill—1,900 cu.yd.	.50	1.00	.60
7. Dike embankment—110,000 cu.yd.	.25	.27	.25
8. Round timber piling—146,000 lin.ft.	.70	.70	.65
9. Concrete piling—2,610 lin.ft.	2.50	2.08	3.50
10. Steel sheet piling, type "A"—49,750 sq.ft.	1.50	1.50	1.35
11. Steel sheet piling, type "B"—19,200 sq.ft.	1.55	1.60	1.35
12. Steel sheet piling, type "C"—24,500 sq.ft.	.50	.80	.60
13. Steel sheet piling, type "D"—46,750 sq.ft.	.55	.80	.75
14. Pile loading test—5, each	500.00	416.15	600.00
15. White oak timber—3 M.F.B.M.	300.00	195.07	325.00
16. Soft wood timber (plain & creo.)—38 M.F.B.M.	150.00	146.04	150.00
17. Derrick stone—10,500 cu.yd.	5.00	5.00	5.00
18. One and two-man stone—14,000 cu.yd.	3.50	3.00	3.10
19. Riprap—7,300 cu.yd.	3.25	3.00	3.10
20. Crushed stone or gravel protec.—8,600 cu.yd.	2.00	2.00	2.60
21. Stored stone protection—5,000 cu.yd.	2.25	4.50	3.00
22. Rehandled stone protection—5,000 cu.yd.	1.50	.50	1.50
23. Slushing concrete—1,000 cu.yd.	8.00	12.00	12.00
24. Class "A" concrete—675 cu.yd.	25.00	28.53	25.00
25. Class "B" concrete—36,700 cu.yd.	13.00	13.00	12.40
26. Steel, service bridge—1,438,000 lb.	.08	.08	.08
27. Steel, tainter gate—1,495,000 lb.	.105	.105	.105
28. Steel, roller gate—860,000 lb.	.115	.115	.115
29. Steel, miscellaneous—685,000 lb.	.095	.095	.095
30. Steel, manganese—263,000 lb.	.087	.09	.087
31. Steel, chromium—80,000 lb.	.12	.12	.12
32. Reinforcing steel—1,175,000 lb.	.05	.05	.05
33. Corrosion-resisting steel—16,800 lb.	.70	.70	.70
34. Steel forgings—218,000 lb.	.17	.17	.17
35. Nickel steel forgings—2,425 lb.	.27	.35	.27
36. Chromium steel forgings—13,500 lb.	.22	.28	.22
37. Steel castings—250,000 lb.	.15	.15	.15
38. Alloy steel castings—29,000 lb.	.25	.32	.25
39. Iron castings—1,350 lb.	.25	.16	.12
40. Bronze—5,950 lb.	.55	.72	.55
41. Copper—240 lb.	.55	.72	.55
42. Lead—650 lb.	.22	.29	.22
43. Wrought iron pipe, black std. 6 in.—350 lin.ft.	5.00	3.00	4.00
44. Wrought iron pipe, black std. 3 in.—380 lin.ft.	2.50	1.38	1.50
45. Wrought iron pipe, black std. ¾ in.—200 lin.ft.	1.00	.39	.50
46. Wrought iron pipe, black std. ½ in.—500 lin.ft.	.75	.36	.50
47. Copper tubing, 1 in.—870 lin.ft.	1.00	.54	1.15
48. Fiber conduit, 4 in.—100 lin.ft.	1.00	.57	1.00
49. Fiber conduit, 3 in.—850 lin.ft.	.75	.52	.70
50. Rigid metal conduit, 3 in.—110 lin.ft.	3.50	3.90	1.75
51. Rigid metal conduit, 2 in.—10 lin.ft.	2.00	2.60	2.00
52. Rigid metal conduit, 1½ in.—600 lin.ft.	1.00	1.10	1.25
53. Rigid metal conduit, 1¼ in.—40 lin.ft.	.90	1.04	1.25
54. Rigid metal conduit, 1 in.—140 lin.ft.	.80	.52	1.15
55. Rigid metal conduit, ¾ in.—200 lin.ft.	.75	.58	1.00
56. Elec. grounding system—job	300.00	171.00	500.00
57. Crane track, 80-lb. rail—1,272 trk.ft.	4.50	4.50	4.50
58. Steel pipe railing—1,306 lin.ft.	2.00	2.00	2.00
59. Steel floor grating—131 sq.ft.	3.00	4.55	3.00
60. Moulded rubber seals—6,100 lb.	1.50	1.50	1.50
61. Roller gate operating mach.—3, each	27,500	25,000	27,500
62. Roller gate operating mach. spare pt. s—1 lot	8,000	2,600	8,000
63. Roller gate operating house—4, each	5,000	4,000	4,000
64. Tainter gate operating mach.—8, each	17,000	17,000	17,000
65. Tainter gate heaters, 6, each	700.00	910.00	700.00
66. Tainter gate heater, spare parts—job	550.00	715.00	550.00
67. Roller gate heaters—3, each	4,000	4,000	4,000
68. Roller gate heater, spare parts—job	2,200	2,861	2,200
69. Install loco. crane on service bridge—job	1,500	1,500	2,000
70. Storage yard truck—10, each	550.00	550.00	550.00
71. Service bridge truck—2, each	1,500	1,500	1,500
72. Central control station—job	27,500	24,000	25,000

Indiana State Highways

TWENTY-TWO AND ONE-HALF MILES of 20-ft. reinforced concrete pavement under construction in Indiana indicate average costs per mile of $24,500 for this type of surfacing. On a 14-mile stretch the low bid for concrete of $22,726 per mile compared with $22,884 for bituminous macadam type. The following tabulations list the unit prices and totals of the three low bidders on two projects awarded late in 1936.

I—Decatur County

13.964 mi. reinf. concrete, with bituminous concrete alternate.

(A) Bigler Paving Co. (contract) Middletown, O. $317,345.

(B) Meshberger Bros. Stone Co. (bituminous concrete) Linngrove, Ind. $319,556.

(C) R. McCalman Inc. Danville, Ind. $328,330.

II—Steuben County

8.712 mi. reinf. concrete.

(D) Grace Construction & Supply Co. (contract) Fort Wayne, Ind. $242,640.

(E) Brooks Construction Co., Fort Wayne, Ind. $255,194.

(F) Moellering Construction Co., Fort Wayne, Ind. $263,472.

I—DECATUR COUNTY

Item	A	B	C
1. Crushed stone, gravel, cl. C.—1,257 cu.yd.	$2.50	$2.00	$2.50
2. Common excav.—26,259 cu.yd.	.30	.40	.35
3. Special borrow—4,471 cu.yd.	.30	.35	.30
4. Overhaul—2 balances—169 cu.yd.	.20	.20	.20
5. Struct. concrete, spec.—6.8 cu.yd.	20.00	25.00	22.00
6. Struct. concrete, D—111.1 cu.yd.	20.00	20.00	22.00
7. Reinf. steel, struct.—5,764 lb.	.05	.05	.04
8. Brick catch basins—3 each	125.00	125.00	75.00
9. Std. brick inlets—2 each	100.00	130.00	85.00
10. Manhole, type B—1 each	100.00	100.00	85.00
11. Finish shoulders, ditches—71,869 lin.ft.	.15	.15	.15
12. Sodding, fertilized—3,070 sq.yd.	.17	.25	.20
13. Aggreg. for drains—917 cu.yd.	2.20	3.00	2.00
14. Paved side ditch—490 lin.ft.	1.10	.90	1.00
15. Comb. curb, gutter—3,857 lin.ft.	1.25	1.00	1.00
16. Sidewalk removal—780 sq.yd.	.40	.10	.50
17. Flex. steel plate guard rail—5,623 lin.ft.	.80	1.00	.75
18. Monuments, C—5 each	10.00	10.00	6.00
19. Salvaged road material—25 cu.yd.	1.00	1.80	1.00
20. Reinf. conc. slab, R.R. crossing—85 sq.yd.	10.00	12.00	10.00
21. Guide posts—122 each	1.50	1.50	1.40
22. Dressing, sodding—42,767 sq.yd.	.19	.27	.20
23. C.M. pipe, 12 in.—96 lin.ft.	1.30	1.25	1.00
24. C.M. pipe, 15 in.—60 lin.ft.	1.70	1.50	1.50
25. R.C.V.C. or C.I. pipe, 15 in.—64 lin.ft.	1.70	1.50	2.00
26. R.C.V.C. or C.I. pipe, 24 in.—116 lin.ft.	3.10	3.00	2.50
27. R.C. or V.C. pipe, 12 in.—48 lin.ft.	1.30	1.25	1.00
28. R.C. or V.C. pipe, 15 in.—76 lin.ft.	1.70	1.50	1.50
29. Pipe, misc., 12 in.—92 lin.ft.	1.30	1.25	1.00
30. Pipe, misc., 15 in.—86 lin.ft.	1.70	1.50	1.50
31. Sewer pipe, misc., 12 in.—478 lin.ft.	1.30	1.00	.80
32. Sewer pipe, misc., 18 in.—230 lin.ft.	2.15	2.25	1.75
33. Relaid pipe, 15 in.—22 lin.ft.	.70	1.00	.50
34. V.C. pipe, 12 in.—56 lin.ft.	1.70	1.25	.90
35. Bitum. coated sewer, 6 in.—738 lin.ft.	.70	.70	.50
36. Bitum. coated drain, 6 in.—400 lin.ft.	1.00	.70	.50
37. Perf. misc. drain, 6 in.—2,648 lin.ft.	.60	.60	.45
38. Perf. C.M. drains, 6 in.—900 lin.ft.	1.00	.65	.75
39. Spec. V.C. pipe inlet—1 each	50.00	25.00	18.50
40. Reinf. steel, pavement—15,089 lb.	.04	.....	.04
41. Expansion joints—29,798 lin.ft.	.50	.....	.35
42. Expansion jts. "D"—7,656 lin.ft.	.60	.....	.35
43. Expansion jts., cork, rubber—404 lin.ft.	.50	.....	.40
44. Expansion jts., ½ in. bitum.—1,295 lin.ft.	.10	.....	.12
45. Monuments, D—9 each	10.00	.....	2.25
46. Reinforced concrete pavement—166,132 sq.yd.	1.46	.....	1.35
47. Screenings, waterbound base, B—16,912 ton	.....	1.35	.....
48. Subgrade, fine aggreg., C or D—9,067 ton	.....	1.35	.....
49. Aggreg. bitum. mac. base B—26,643 ton	.....	1.50	.....
50. Coarse aggreg., waterbd. base, B—56,492 ton	.....	1.50	.....
51. Bitumen, 1st and 2nd coats—212,805 gal.	.....	.09	.....
52. Bitumen, 3rd coat—51,074 gal.	.....	.09	.....
53. Bitum. conc. A.H. type B—12,460 ton	.....	6.00	.....
54. Concrete header—158 lin.ft.	.....	2.00	.....
55. Monuments, type B—9 each	.....	20.00	.....

II—STEUBEN COUNTY

Item	D	E	F
1. Excavation, common—161,440 cu.yd.	$0.23	$0.28	$0.25
2. Excavation, peat—22,860 cu.yd.	.12	.20	.18
3. Excavation, borrow—1,782 cu.yd.	.22	.31	.28
4. Excavation, borrow B—54,903 cu.yd.	.22	.32	.28
5. Overhaul—243 cu.yd.	.05	.05	.10
6. Struct. concrete, spec.—279 cu.yd.	17.00	20.50	22.00
7. Struct. concrete D—214 cu.yd.	17.00	21.50	20.00
8. Reinf. steel, struct.—35,418 lb.	.04	.04	.045
9. Finish shoulders, ditches—42,208 lin.ft.	.11	.08	.11
10. Sodding, fertilized—59,594 sq.yd.	.17	.16	.17
11. Aggregate, subsurf. drains—544 cu.yd.	1.75	1.50	2.00
12. Riprap—145 sq.yd.	1.50	1.00	3.50
13. Paved side ditch—4,584 lin.ft.	.65	.60	.85
14. Pavement removal—2,540 sq.yd.	.30	.50	.25
15. Test holes—3,282 lin.ft.	.20	.15	.25
16. Dynamite—566 lb.	.30	.40	.25
17. Machine operation—99 hrs.	5.00	6.00	4.00
18. Final blasting—1,131 lin.ft.	1.00	1.00	1.50
19. Flex. steel plate guard rail—7,636 lin.ft.	.65	.70	.80
20. Guide posts—121 each	1.25	1.00	1.25
21. Std. R. C. spring box—1 each	20.00	25.00	50.00
22. Salvaged bitum. road material—975 cu.yd.	.50	1.50	1.00
23. Aggreg. bitum. mac. surf. cl. A.—1 ton	3.50	3.00	5.00
24. Bitum. for bit. mac. surf.—5 gal.	.25	.25	.50
25. Stone, gravel surface—700 cu.yd.	2.00	1.50	2.00
26. Sub. drains, conc., V.C., 6 in.—2,716 lin.ft.	.35	.65	.40
27 Bit. coated drains, conc., V. C., 6 in.—1,090 lin.ft.	.38	.75	.50
28. Bit. coated C.M. drains, 6 in.—270 lin.ft.	.60	1.05	.85
29. Perf. C.M. drains, 6 in.—330 lin.ft.	.56	.95	.80
30. Relay R.C. pipe, 15 in.—394 lin.ft.	.70	.80	1.00
31. Relay R.C. pipe, 18 in.—28 lin.ft.	1.00	.90	1.10
32. Relay C.M. pipe, 15 in.—36 lin.ft.	.70	.70	1.00
33. Pipe, V.C. or R.C., 18 in.—174 lin.ft.	1.40	1.55	1.75
34. Reinf. conc. pipe, 15 in.—340 lin.ft.	1.15	1.35	1.60
35. Reinf. conc. pipe, 18 in.—32 lin.ft.	1.40	1.55	1.75
36. C.M. pipe, 12 in.—1,358 lin.ft.	1.00	1.05	1.00
37. C.M. pipe, 15 in.—824 lin.ft.	1.10	1.30	1.35
38. C.M. pipe, 24 in.—144 lin.ft.	2.00	2.15	2.50
39. Bit. coat C.M. pipe, 18 in.—80 lin.ft.	2.00	1.60	2.00
40. Bit. coat C.M. pipe, 24 in.—66 lin.ft.	2.75	2.50	3.00
41. V.C. R.C. or C.I. pipe, 15 in.—348 lin.ft.	1.10	1.35	1.60
42. V.C. R.C. or C.I. pipe, 18 in.—2 2 lin.ft	1.20	1.55	1.75
43. V.C. R.C. or C.I. pipe, 24 in.—128 lin.ft.	1.70	2.35	2.50
44. Misc. pipe, 12 in.—236 lin.ft.	1.00	1.15	1.00
45. Misc. pipe, 15 in.—252 lin.ft.	1.10	1.35	1.35
46. Cem. conc. or V.C. sewer, 8 in.—120 lin.ft.	.75	.65	.65
47. Drain tile, 8 in.—60 lin.ft.	.40	.60	.80
48. Reinf. conc. pavement—94,508 sq.yd.	1.40	1.34	1.46
49. Expansion joints—20,620 lin.ft.	.53	.48	.32
50. Expansion joints, D—643 lin.ft.	.62	.55	.50
51. Expan. jts., cork, rubber, 1 in.—130 lin.ft.	.50	.40	.50
52. Monuments, D—1 each	5.00	5.00	5.00

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